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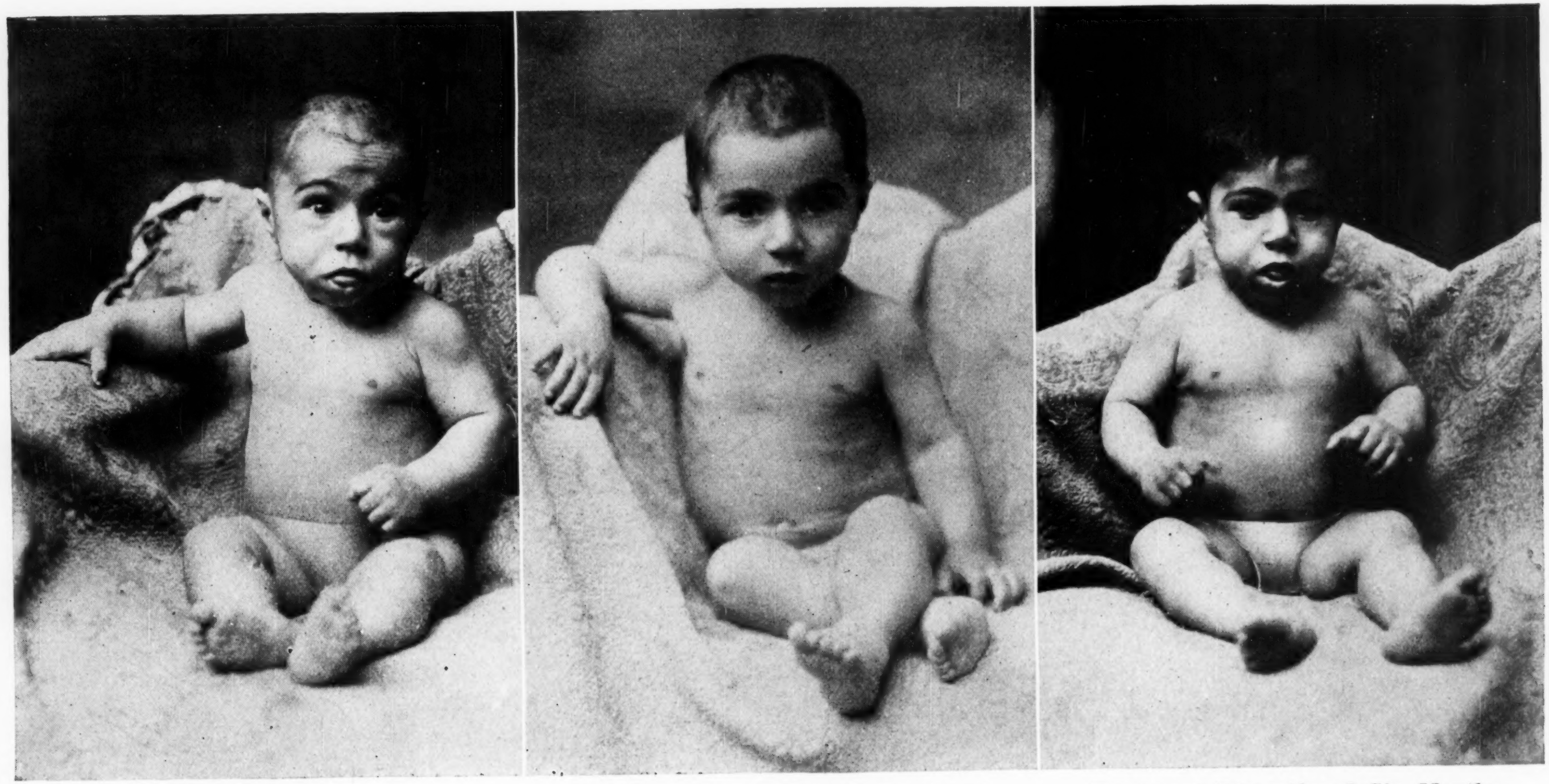


Before Treatment | Three Weeks of Thyroid Treatment | Treatment Discontinued Six Months

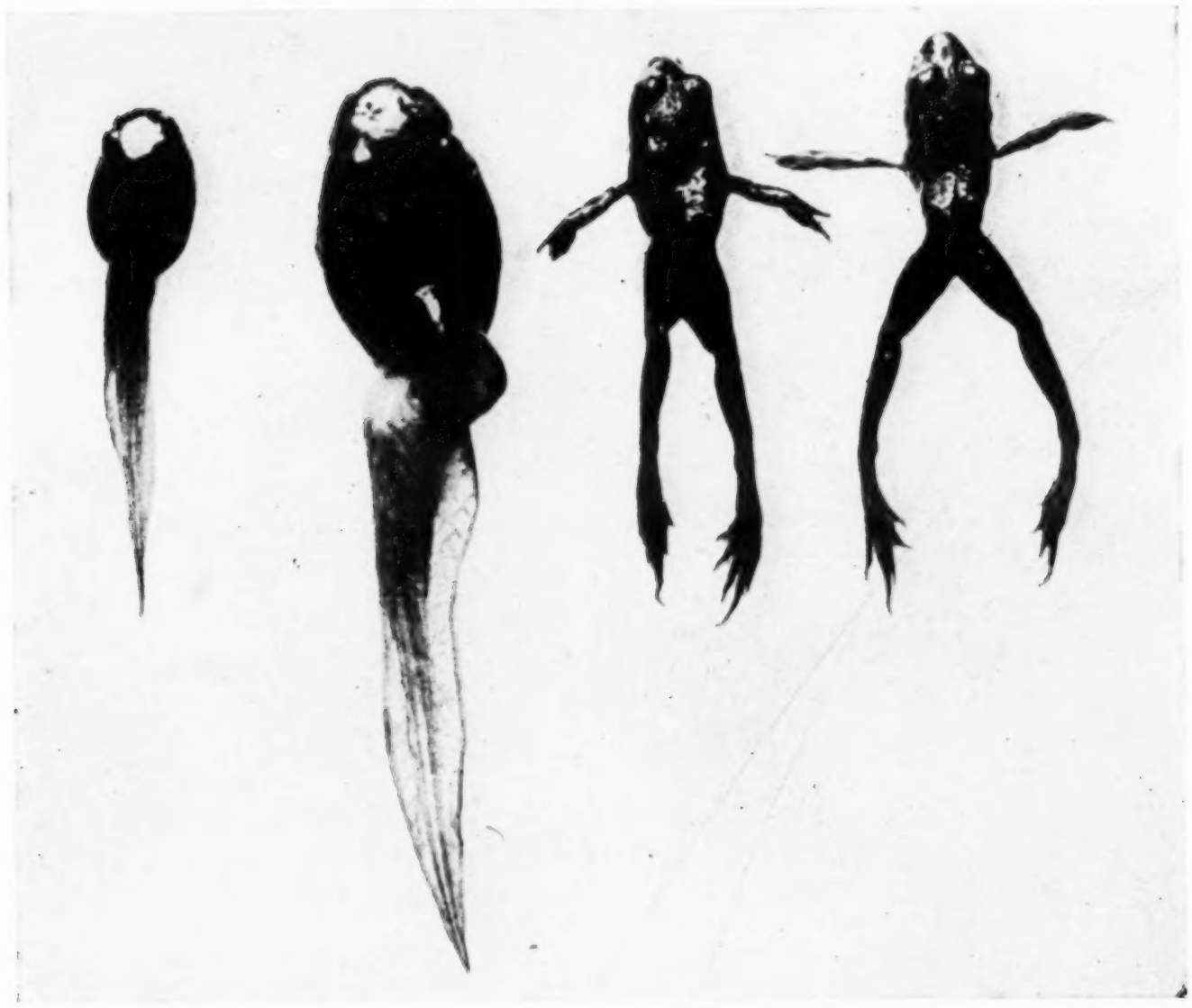
CRETINISM DUE TO THYROID INSUFFICIENCY

FRONTISPIECE. Cretinism is a disease chiefly of young children, caused by congenital absence of the thyroid gland, or to insufficiency of its secretion. Its outstanding symptoms are stunted growth of the body, even more stunted mental development, and thick, flabby skin. The feeding of thyroid extract results in the return of normal mental faculties, and in remarkably rapid physical growth. Treatment must be continued throughout life to prevent the recurrence of symptoms of cretinism. The thyroid gland appears to exert its influence through accelerating metabolism. Evidently the more highly differentiated tissues, especially those of brain and nervous system, are peculiarly dependent on an "internal environment," rich in thyroid secretion, for without it they fail to function properly. The above pictures show three views of the same child, and bring out clearly the almost unbelievable rapidity of the changes that take place when the proper amount of thyroid secretion is present in the body. After treatment had been continued for a time the parents removed the child from medical care, and before long symptoms of cretinism began to reappear. Photograph by Dr. Max G. Schlapp, Clearing House for Mental Defectives, New York City. See text, p. 11.

DUCTLESS GLANDS AND DEVELOPMENT--II*

Amphibian Metamorphosis Considered as Consecutive Dimorphism, Controlled by the Glands of Internal Secretion

JULIAN HUXLEY,
Oxford University, England



"CRETIN" AND NORMAL TADPOLES

FIGURE 1. On the left are two thyroidless tadpoles, showing extremes in size. On the right are two frogs from the same "brood," and of the same age as the tadpoles. The frog on the extreme right had his thyroid removed, but examination showed that part of the gland had been left, and this fragment was sufficient to produce metamorphosis. The distortion of the large tadpole's tail is an abnormality from which both normal and thyroidless tadpoles suffered, supposed to have been due to some impurity in the water. Lack of the thyroid gland does not have an adverse effect on the growth of tadpole tissues. In fact, "tadpole constitution" develops to an unusual size, but typically adult tissues are greatly retarded or do not develop at all. Photograph reproduced by permission of Dr. Bennett M. Allen, and the *Journal of Experimental Zoology*. See text, p. 11.

IF WE try to penetrate a little deeper, we shall be driven to the conclusion that, since the thyroid, so far as is known, has always as its main function the acceleration of general metabolism, the two types of internal environment really differ in regard to metabolic rate, the basal metabolism of the larval stage being less than that obtaining at metamorphosis. We then conclude that the larval tissues are adapted to live at a low, the

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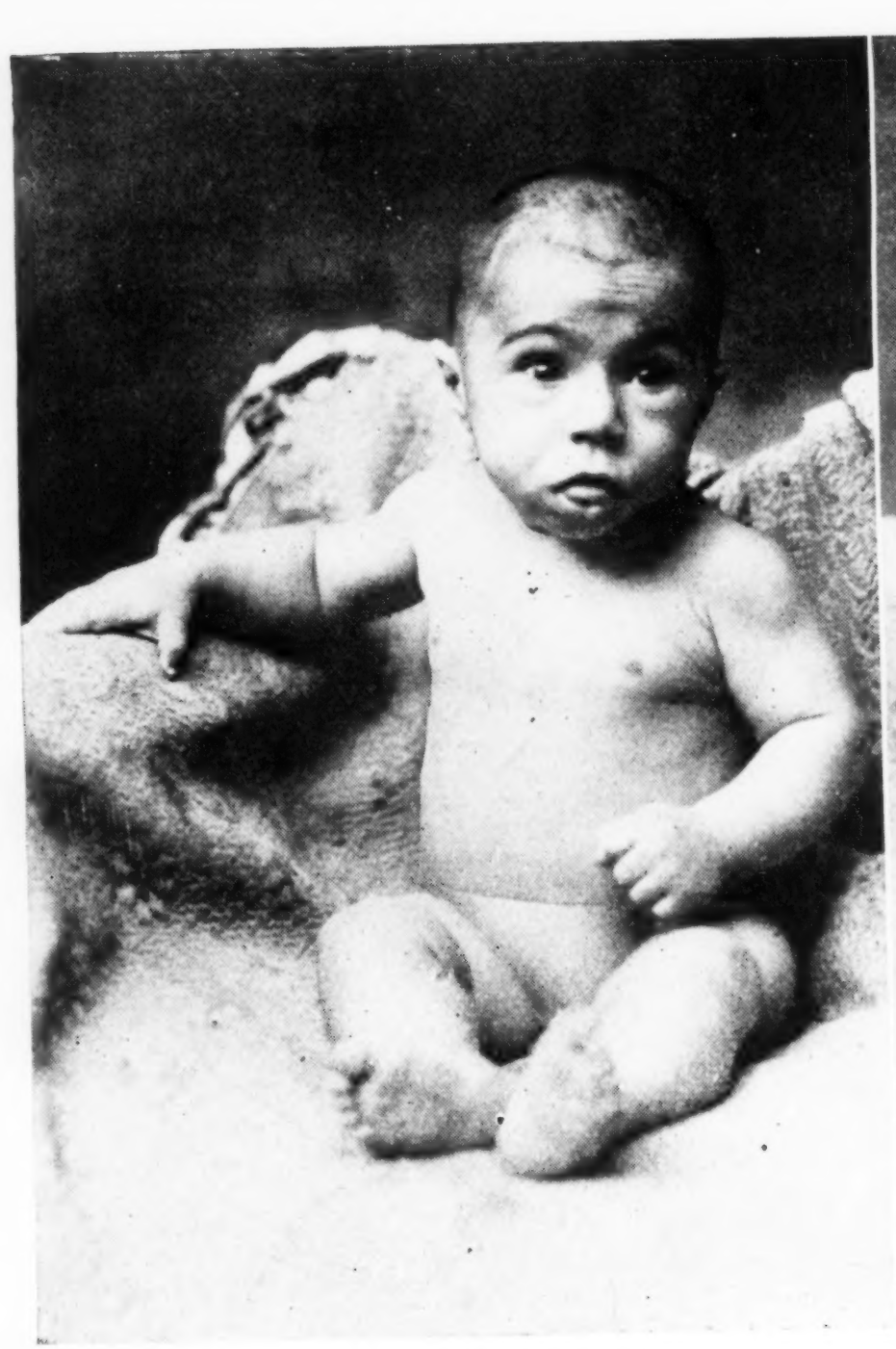

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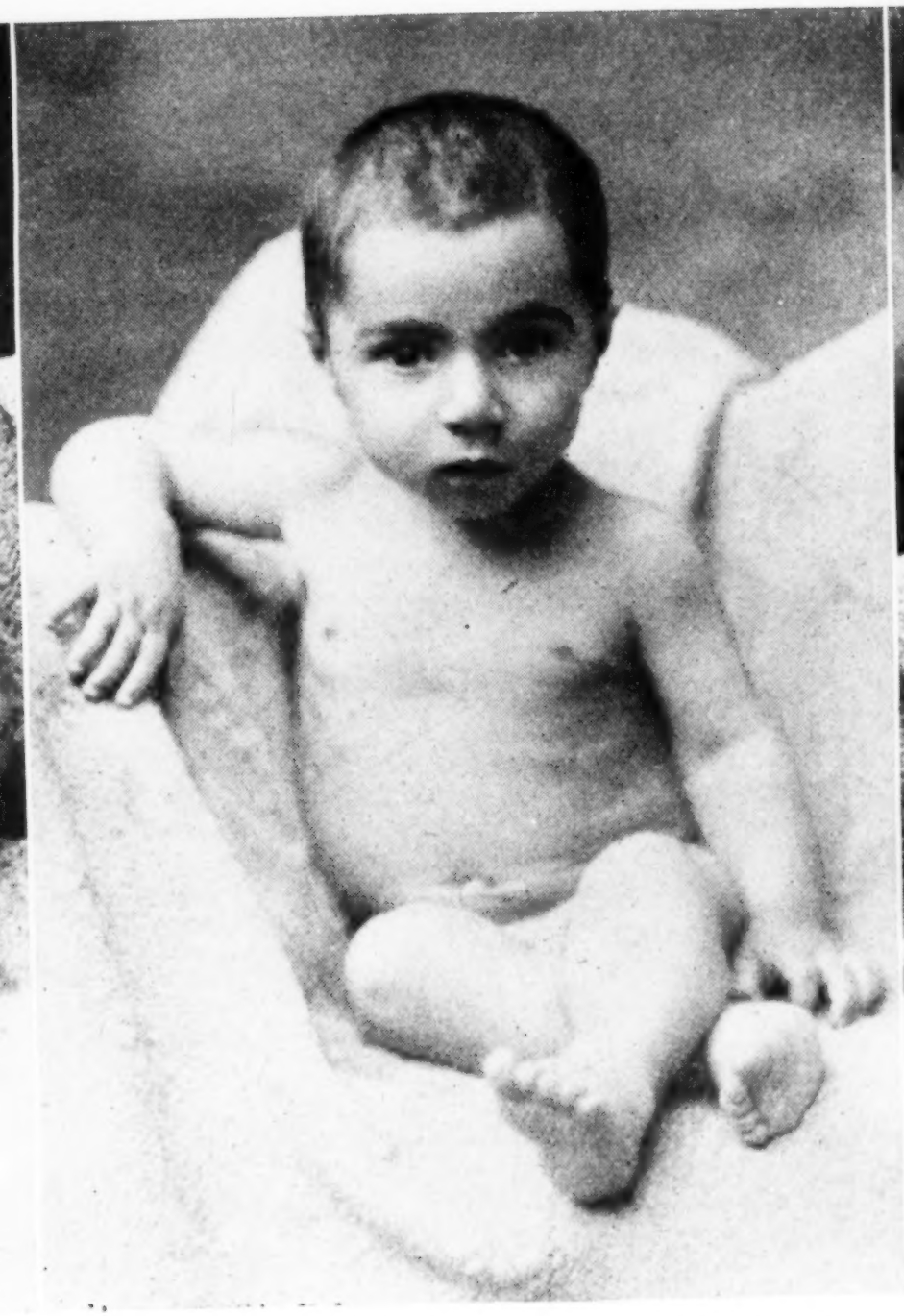
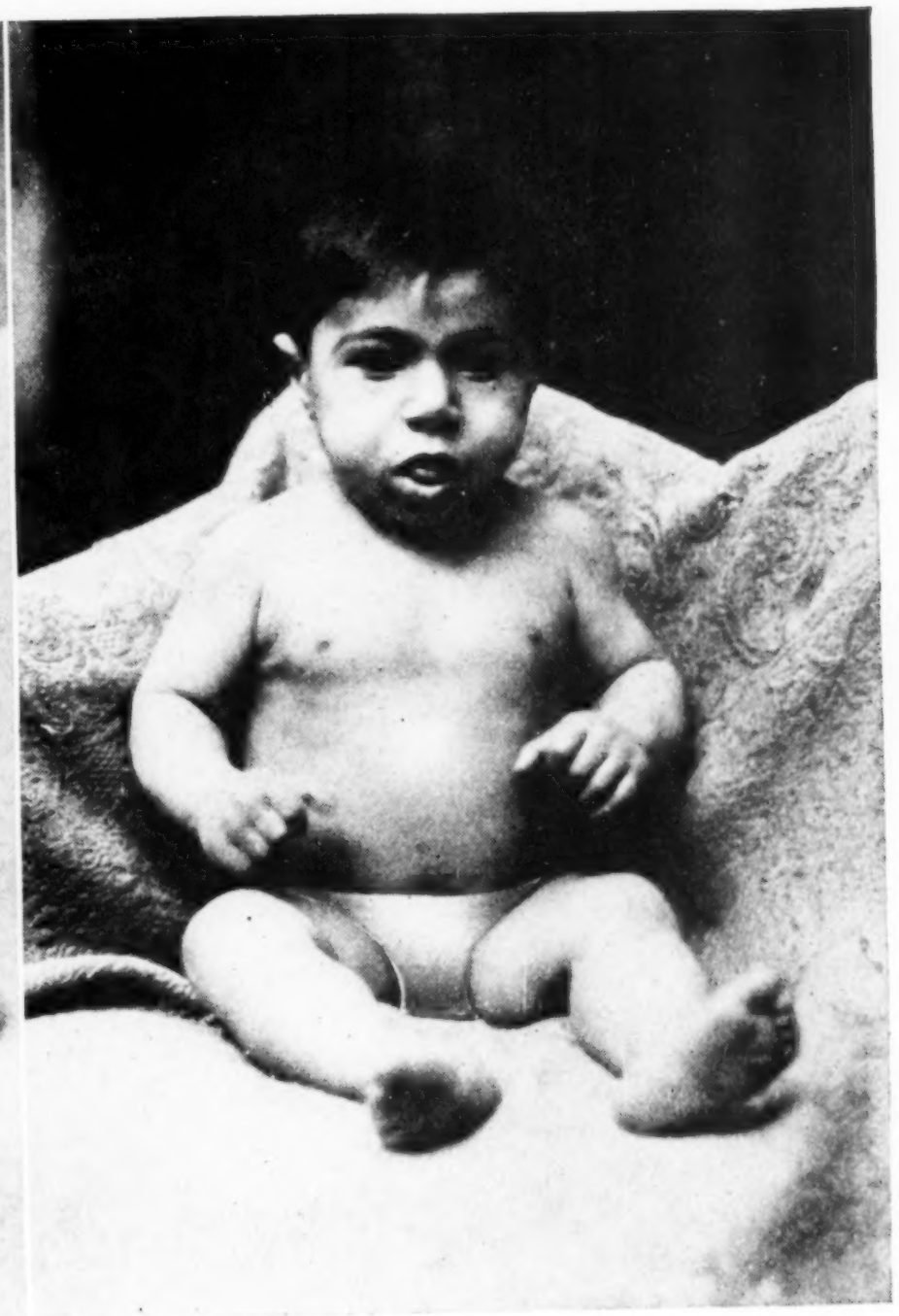


Three Weeks of Thyroid Treatment



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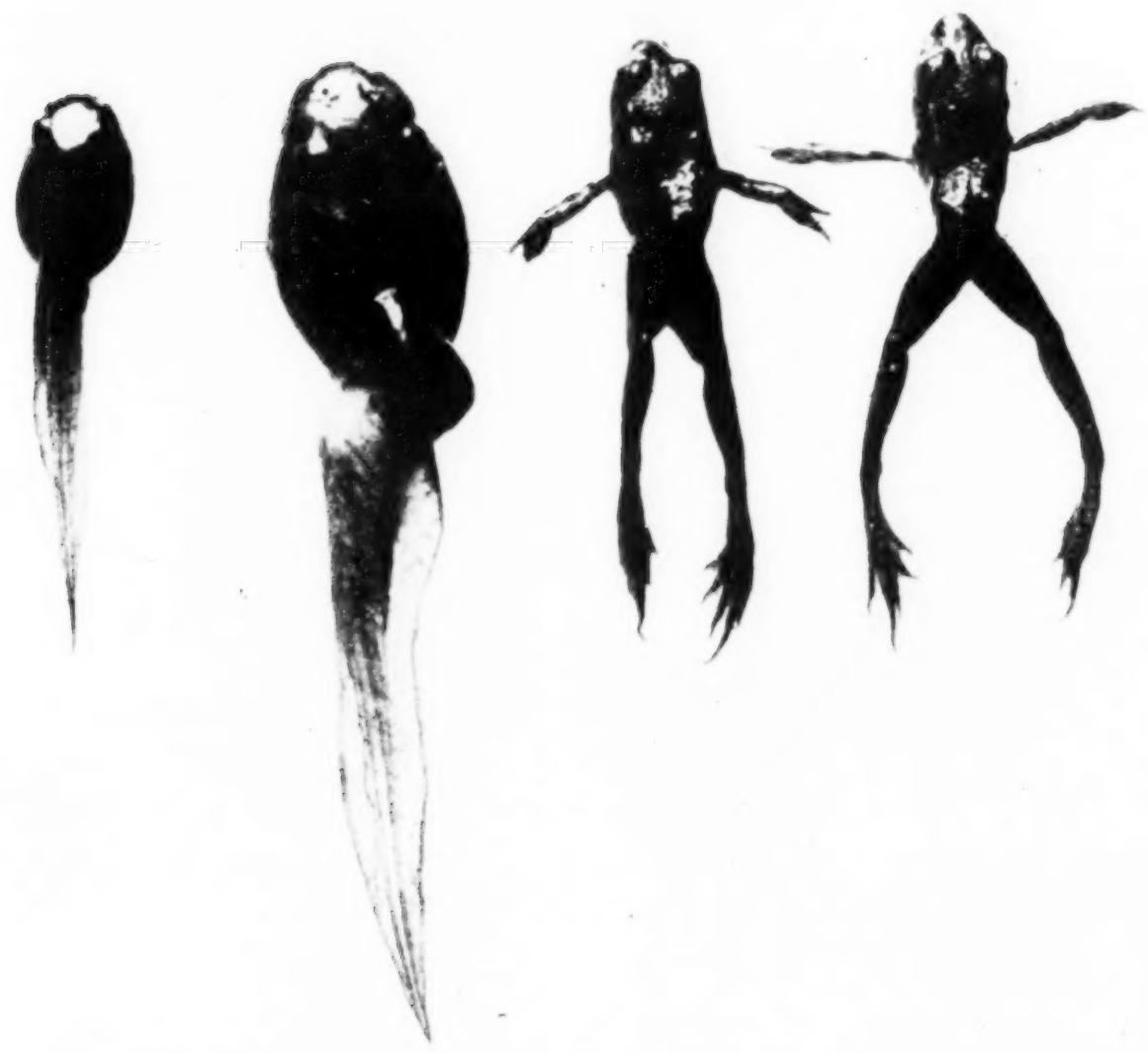

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adult tissues at a higher rate of metabolism, and that when the metabolic level is raised beyond a certain point, the larval tissues break down. That tissues are unable to maintain themselves in a functional state when certain alterations in conditions occur,—in other words, that they *dedifferentiate*—is well known. When all tissues dedifferentiate more or less simultaneously, there is a regression of the whole animal to a simplified state, as in Clavellina. When only some are affected, the result may be a complete resorption of the affected organs, due to migration of the cells into the cavities of the body;[9]* or a beginning of resorption followed by phagocytosis. It is this last method which appears to occur in Amphibian metamorphosis. By starving young tadpoles, I have been able to obtain localized dedifferentiation in small areas of the tail, the histological appearance being very like that which obtains at metamorphosis. In this case, phagocytosis only appears to obtain to a very small extent.

The Mechanism of Metamorphosis

The important researches of Champy have thrown a new light on the threshold values for different tissues. He finds that in frog tadpoles, after a single administration of thyroid, certain tissues respond by a *progressive* increase in the proportion of mitoses, others by a progressive decrease, while still others show no change in growth-rate. What is more, one and the same tissue may show localized areas of all three descriptions, distinguishable solely by their mode of reaction to thyroid-diet. In other words, the action of *thyroxin*, like that of so many other hormones, depends not only on its own specific properties, but also on specific properties of the tissues it affects. As we have said before, there are therefore two classes of variables to be kept in mind in dealing with any problem such as metamorphosis, into which the thyroid enters, variations in *thyroxin* concentration, and variations in the sensitiveness of the tissues.

If this is so, the primary mechanism of metamorphosis should be (a) an adverse effect upon the purely larval tissues, followed by their partial dedifferentiation, this followed by incipient resorption, and this by phagocytosis; (b) an acceleration in the rate of growth of all specifically adult tissues, which are those that are adapted to grow better at a higher rate of metabolism.

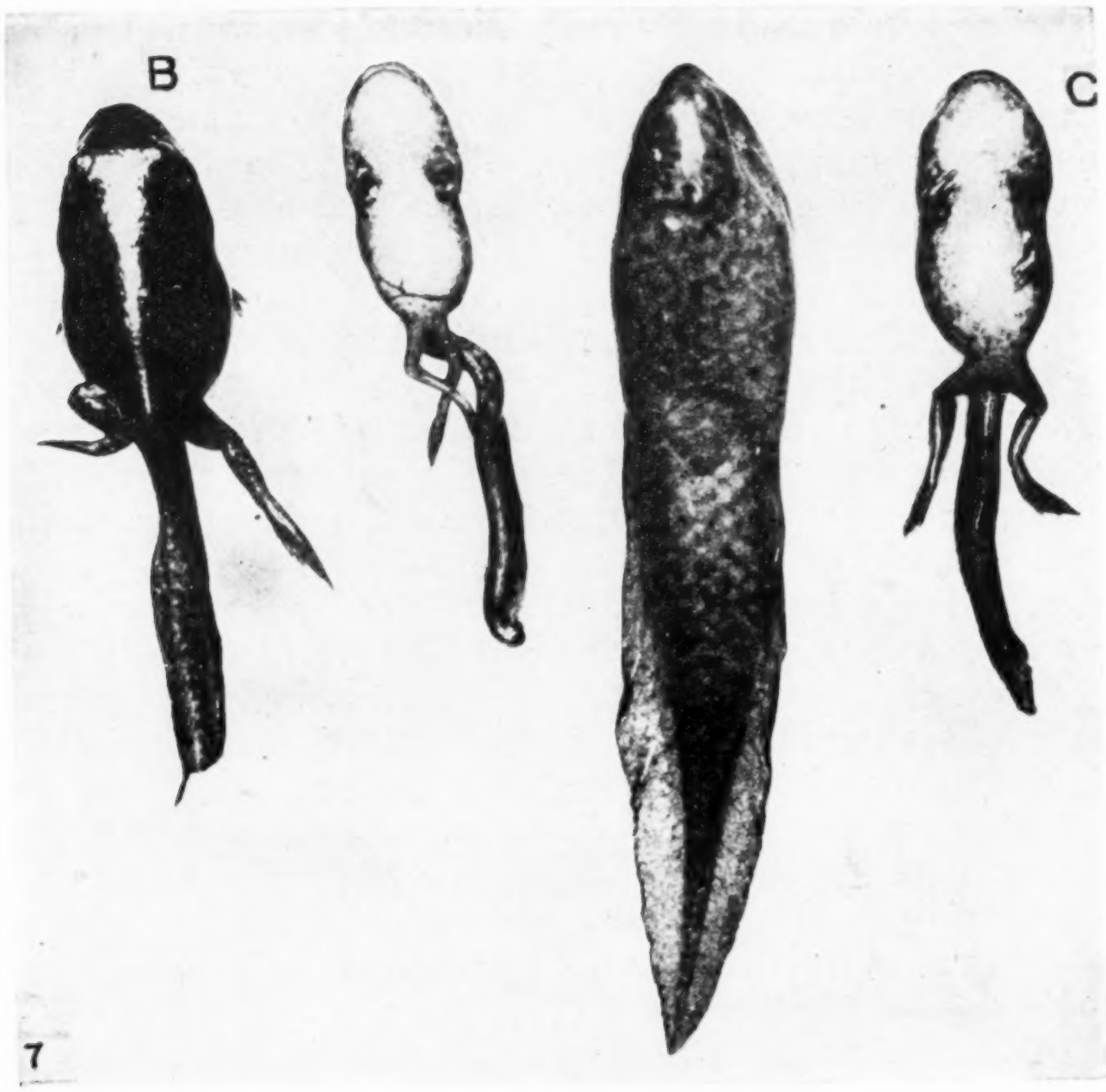
We have in this a general answer to our second principal question, as to the mechanism of metamorphic change. To pursue this point in detail would take us too far afield, and we must content ourselves with the very general statement that certain tissues have a lower optimum metabolic rate for maximum growth, others a higher, and that the former spontaneously break down when the rate is raised too far, their debris being cleared away later by the phagocytes.

Metamorphosed Amphibia, so far as known, show no important morphological changes when their thyroids are removed. If this is corroborated, it shows that the high concentration of thyroid is not necessary for the maintenance of adult structure in the same way that low concentration is necessary for the maintenance of larval structure, and emphasizes the irreversibility of metamorphic processes.

Bearing in mind the idea of the two internal environments, distinguished by different rates of metabolism, we may be able to grasp certain other of our problems more clearly.

In parenthesis, it may be observed that some recent writers, e. g., Swingle[15] and Kendall,[11] believe that the thyroid secretion acts in different ways in Amphibia and in Mammals, the metamorphic effect in the former being due solely to the iodine content of the thyroid hormone, the rise in basal metabolism seen in the latter being due to a specific iodized organic compound,

* For numbered references, see "Literature Cited" at end of article.



THYROID FED TADPOLES AND CONTROL

FIGURE 2. Larvae of the bull frog normally retain the tadpole form for two or even three years before metamorphosis takes place. The changes produced in the three "half-and-half" individuals shown were the result of twenty-six days of thyroid feeding. Notice the great decrease in size that has occurred, the tissues being literally broken down and burned up under the more rapid metabolism produced by increased concentration of thyroid secretion. Photograph reproduced by permission of Dr. W. W. Swingle, and the *Journal of Experimental Zoology*.

thyroxin. Allen[3] seems inclined to adopt the same view.

This hypothesis is based chiefly on the extremely important fact discovered by Swingle[16] and already referred to, that inorganic iodine produces metamorphosis in Anuran tadpoles, and this whether they are normal or have had their thyroids removed.

However, even in adult mammals it has been shown that inorganic iodine in the blood-stream is very rapidly taken up by the thyroid, and is quickly built into some specific organic compound (presumably *thyroxin*). In mammals, therefore, iodine is promptly elaborated by the organism to form part of a complex substance which is the thyroid hormone.

So far as one can judge, exactly the same process is at work in larval Anura. The provision of an amount of iodine greater than the normal, up to the highest concentration tolerated by the animals, results in an increase in the size of the thyroid, and in the amount of its colloid content.[15] On the other hand, when one large dose of thyroid substance is given as food, metamorphosis occurs, but the thyroid remains small, increasing very little, if at all, in volume.[4] In other words, an excess of thyroid hormone acts directly and does not require to be worked up by the animal's own thyroid gland, whereas an excess of free iodine, however great, is worked up by the animal's own glands, presumably into the normal thyroid hormone, before exerting its metamorphic effects.

The final startling discovery by Swingle, that inorganic iodine will metamorphose even thyroidless larvae, at first sight seems to militate against this view. However, as Swingle himself pointed out, it only implies that the general tissues of the body possess to some extent qualities which have been specialized in the thyroid tissue. Uhlenhuth[18, 19], justly points out that we know nothing of the fate of the iodine in the body and that it is easy to suppose that it is worked up as to believe that it acts directly. As a matter of fact, it is easier to believe the former, since Swingle's own results showed that thyroidless animals metamorphosed less rapidly than normal ones in the same concentration of iodine. This would be the case if the same processes were occurring in both, only less rapidly in the thyroidless ones, whereas it would not be so if the total concentration of iodine were the determining factor.

Metabolic Indicators

It must always be remembered that in the adult mammal complex self-regulating mechanisms are at work, which tend to keep the production of the active secretion of any gland within comparatively narrow limits. In the developing Amphibian, however, such regulatory machinery appears not to exist, so that it is easy to obtain a relative increase in the size and productiveness of a particular ductless gland. In the tadpole, therefore, iodine above the normal is incorporated into the thyroid; whereas, in the healthy adult mammal, the balance, after a comparatively small amount has been taken up by the thyroid, is excreted.

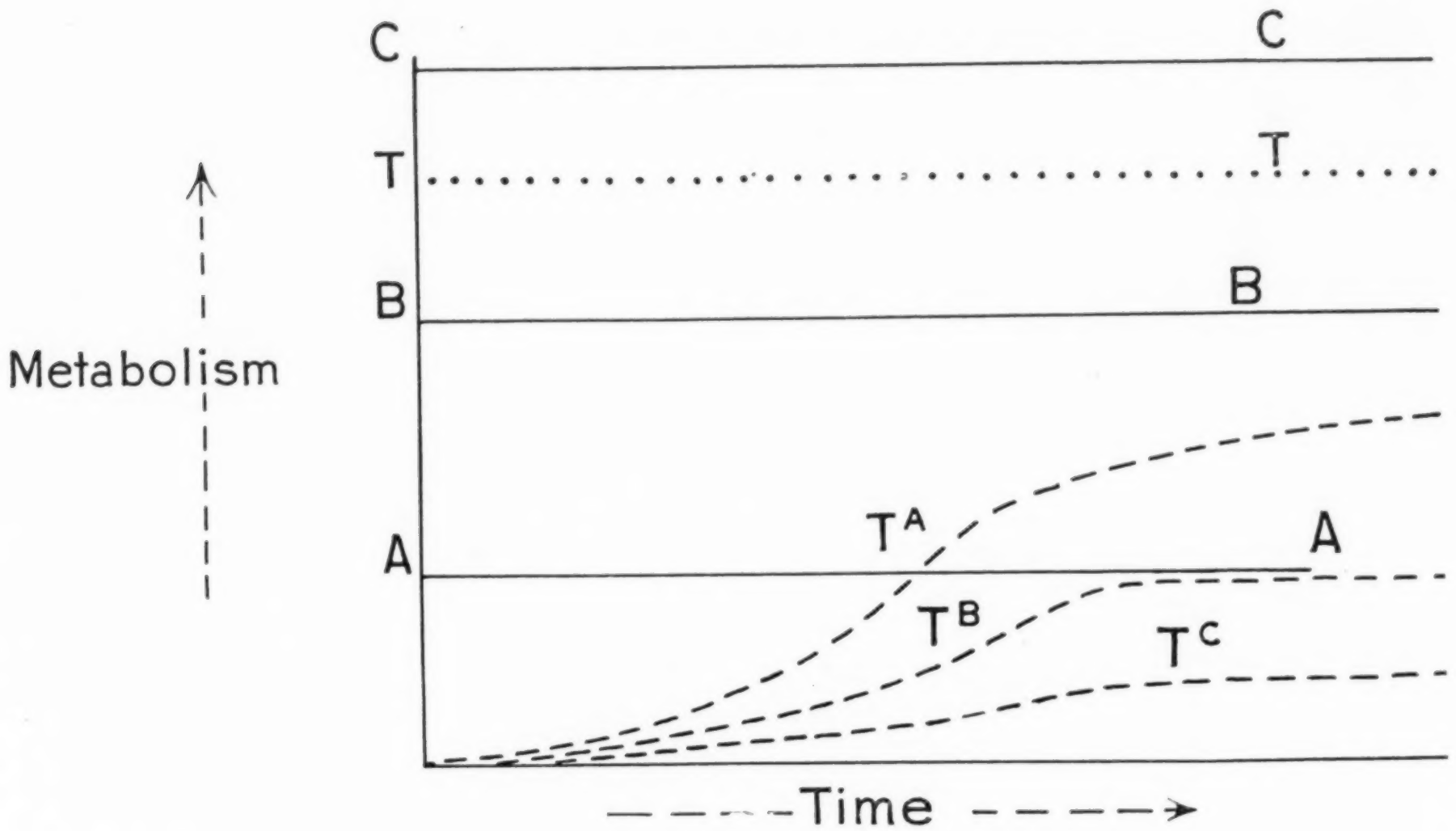
Taking all these facts into consideration, it is fair to say that in Anura, iodine, *during larval life at least*, is a limiting factor for the growth of the thyroid, so that with more iodine, more of the iodized organic compound is formed; further, that in thyroidectomized animals, the same or a similar organic compound is formed, but that it cannot be formed so rapidly or in such large quantities by the unspecialized general tissues as by the thyroid, which has been specialized for this particular function.

Further, the failure of iodine alone to produce metamorphosis in Axolotls and at least some other Urodela, whereas thyroid is effective, is impossible to reconcile with the hypothesis.

The evidence at present strongly indicates that inorganic iodine exerts any metamorphic effects it may have in Amphibia in the same way as it exerts any therapeutic effects it may have in Mammalia, indirectly, through the thyroid gland; and the onus of proving that the substance which exerts an effect upon Amphibian metamorphosis is not the same as that which causes a rise of basal metabolism in mammals, rests on those who propound such a theory.

This is of considerable importance, since, if the effect of thyroid upon Amphibiam metamorphosis is of the same nature as its effect upon human basal metabolism, the Amphibia, so soon as an accurate quantitative method is devised, can be used as "metabolic indicators," and will be of the greatest value as such; whereas they will not have this value to physiological science if the thyroid secretion acts on them in a different way from what it does in mammals.

If it is possible to have tissues which can only maintain themselves below a certain level of metabolism, it is equally possible to have similar tissues adapted to a higher rate, and thus not breaking down until a higher relative concentration of thyroid secretion is reached in the organism. It should equally well be possible to have tissues which did not undergo general breakdown (apart from some wasting away due to increased metabolism) under the influence of the greatest concentration of thyroid substance artificially producible in the organism, any more than do the adult tissues of Amphibia and those of mammals as



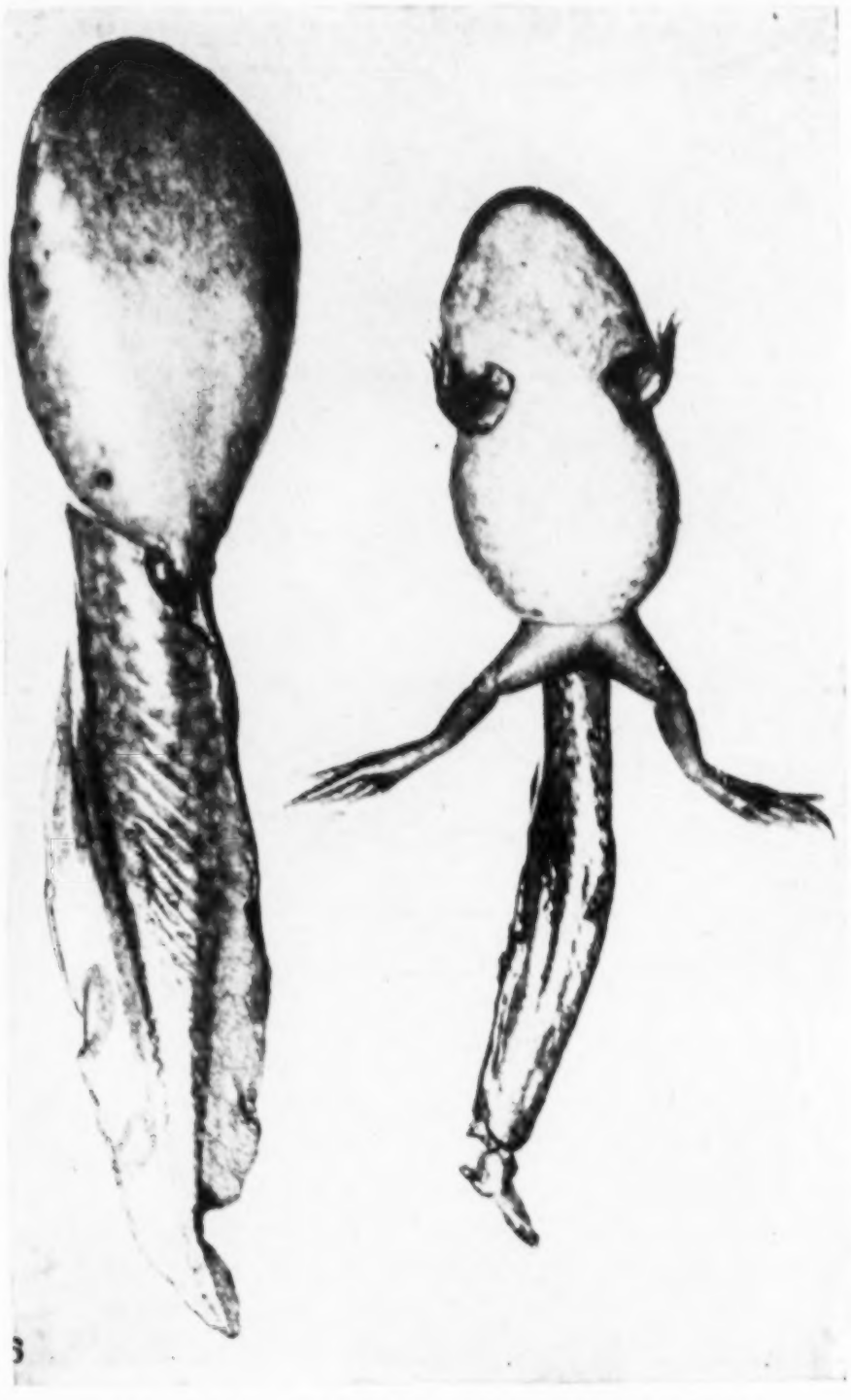
TISSUE SENSIBILITY AND THYROID FEEDING

FIGURE 3. A-A, B-B, C-C, tissue sensitivity (levels of metabolic rate at which breakdown of larval organs occur), in Anura, Axolotl, and Necturus, respectively; T-T, maximum metabolic effect possible to produce by thyroid feeding; Ta, Tb, Tc, curves of thyroid growth for Anura, Axolotl, and Necturus, respectively. Only in the case of Anura does the rate of thyroid growth enable it to secrete a sufficient concentration of thyroid to produce metamorphosis. By artificial thyroid treatment it is possible to increase the metabolic rate of Axolotls to the metamorphic point, but the greatest concentration of thyroid that Necturus will tolerate does not serve to break down the larval tissues.

the result of heavy thyroid doses. It would appear that it is in this way that Necturus, for instance, has become permanently larval in form and immune from the metamorphic effects of thyroid. In Proteus,[12] and Necturus,[17] the histological structure of the thyroid is normal, but its size, especially in Proteus, is relatively small. This in itself will render normal metamorphosis difficult or impossible, but it will not explain why no amount of thyroid treatment will induce metamorphosis. This latter fact, it seems to me, is only explicable on the assumption that a change has occurred in the other partner, so to speak, in the business of metamorphosis—the larval tissues—rendering them insusceptible of breakdown under increased metabolism. That larval tissues may thus differ in different species in their metabolic relations is shown by the interesting observation of Allen[3] that different species of Amphibia when thyroidectomized, attain different degrees of development before differentiation ceases; thyroidless *Bufo lentiginosus* larvae, for instance, attain greater limb-development than thyroidless *Rana pipiens* larvae.

In the Axolotl, the same two processes are probably at work. There is probably a relative insufficiency of thyroid secretion, and this relative insufficiency is due partly to an absolutely decreased rate of differentiation and a decreased end-size of the thyroid itself, partly to a change in the metabolism of the body in general; but neither of these changes seem to have gone so far as in Necturus. Experiments are now being undertaken to test the correctness of this view.

The longer time necessary to metamorphose a mature than an immature Axolotl by thyroid feeding, already alluded to, is interesting in this connec-



THREE WEEKS OF THYROID FEEDING

FIGURE 4. Control and thyroid-fed tadpoles after twenty-three days of thyroid feeding show the terrific acceleration in development that an increased concentration of thyroid secretion produces. Accompanying these external changes are even more remarkable internal ones. In two weeks, the undifferentiated alimentary of the tract of the tadpole decreased in length 246 milimeters (nearly ten inches), and from a simple tube differentiated into stomach, intestine, and the other parts constituting the digestive system of the normal adult frog. Photograph reproduced by permission of Dr. W. W. Swingle and the *Journal of Experimental Zoology*.

tion. The mature tissues, it would appear, do not break down so readily as the immature under the action of thyroid secretion. A rough diagram, which is intended only as a graphic symbol, may help clarify this argument. (Fig. 3.)

If we accept this view, we might expect to find that Anura, as the group in which metamorphosis is the most specialized, show an increased susceptibility of their larval organs to thyroid concentration. That this may possibly be so is shown by Uhlenhuth's discovery[9] that iodine in some Urodeles at least, is not efficacious in bringing about metamorphosis.

The fact that Axolotls and other Urodeles do not metamorphose under simple iodine treatment would then indicate, as suggested above, that their larval tissues are less susceptible to increase in basal metabolism, so that the limited amount of increase which iodine can bring about in the thyroid, even when free iodine is present in the greatest amount which the animals will tolerate, is insufficient to do what larger quantities of thyroid can effect.

Use of the Thyroid a Matter of Convenience

It is further clear that normal utilization of the thyroid by Amphibia as an initiator of metamorphosis is a matter of convenience, so to speak, not of necessity. When metamorphosis does occur, and there is therefore a marked consecutive dimorphism, the general problem is primarily of causing the larval tissues to break down at a given time, and secondly, of causing the more rapid growth of adult tissues. Whatever change of external or internal environment may be found which will promote this breakdown, may be utilized to promote metamorphosis.

In insects it is known that the whole type of metabolism alters at metamorphosis, indicating a pronounced qualitative change of internal environment. In Echinoids, the writer has recently suggested that the sinking of the larvae to the bottom, as the result of the increasing weight of the Echinus rudiment, may be the initiatory factor in metamorphosis, since the benthic environment is unfavorable to the larval tissues, adapted as they are to the totally different conditions of planktonic life.[10] If this should be sub-

stantiated, the change of environment which appears to initiate metamorphosis would here be external, not internal.

To revert, however, to our special problem of Amphibian metamorphosis. We have seen that the consecutive dimorphism of metamorphosis is comparable to that of certain types of hermaphroditism. It remains to point out that, if such were of advantage to the organisms, it would be easy, theoretically, to establish a simultaneous dimorphism similar to that of bisexual organisms. If in an animal like the Axolotl, for example, in which the balance between thyroid and other tissues is fairly close, a mutation were to occur that would result in bringing about metamorphosis, then if we call this the mutant factor T and the normal factor t, we should have metamorphosing animals of classes TT and Tt and neotenous individuals of class tt. It this condition were advantageous, it could no doubt be perpetuated, as is the dimorphism of Primula in regard to style-length. As a matter of fact, it is impossible to imagine that such a condition could be of biological advantage: none the less the illustration is useful as showing the very close connection which exists between the mechanism of metamorphosis and that of sex-dimorphism. I will not press the point; those interested can work out for themselves comparisons with gynomonoecism and various other kinds of sex-distribution.

A further interesting parallel with sex is provided by the unpublished observations of Dr. Hogben, to whom many thanks are due for permission to mention them. Certain combinations of anterior and posterior pituitary treatment, it seems, lead to the establishment of an apparently permanent state intermediate between the larval and the adult form, and comparable to the balanced triploid intersexes of Bridges' Drosophila (in *Science*, New Series 54:252, 1921).

Other Factors

The problem has thus far been simplified by omitting almost completely all references to other factors, which, like the pituitary, have an effect upon metamorphosis.[2, 7, 17, 14]

These, however, seem usually to produce this effect indirectly, by acting upon the thyroid, and can, therefore, for the purposes of an essay such as this, be logically included under the general heading "rest of the body," or the "general larval organization."

It is clear, however, that the "general organization" is very complicated, and that its effect on metamorphosis is theoretically separable into a number of single factors, all of which can be considered as coming into a relationship, whether positive or negative, with the effect of the single factor of thyroid-differentiation. In precisely similar fashion, the work of Bridges shows that as regards sex we have on the one hand the single factor (using the word not in its technical but in its general sense) of the sex-chromosome which may be present in single or in double dose, and on the other hand the operation of a number of factors, namely individual genes scattered throughout the autosomes, some exerting effects antagonistic, others effects complementary to that exerted by the sex-chromosome.

It is clear that the more we know about these individual factors, the further will our analysis proceed. What I would specially like to point out is this: metamorphosis provides a clearly defined and easily recognizable reaction, which throws light on certain important processes occurring in the organism; it may in this respect be compared with the visible reaction of litmus or other indicators to changes in hydrogen-ion concentration.

The Physiology of Development

But what is of special interest, if the views that I have been expressing are well-founded, is that the phenomena

for which metamorphosis acts as an indicator are processes of differentiation and that it is their *relative rates* which are important. We are introduced to a possibility of studying by experimental means a field which so far has scarcely been accessible save to observation—I mean the time-relations of development. So far, the science of Developmental Physiology has sought to establish simple causal relations between particular developmental happenings within or without the organism. It has established the optimum, minimum, and maximum temperatures for the development of many organisms, the chemical substances necessary for growth, the abnormalities produced by alterations in the medium. It has further found that certain organs may exert "formative stimuli," to use Herbst's well-known phrase, upon the development of other organs. Classical examples of these are the influence of the optic cup of vertebrates upon lens-formation, and the influence of the optic ganglion and antennary centre of Crustacea upon the form of the structure regenerated after the eye-stalk is cut off.

But Developmental Physiology can hardly be said to have entered upon its quantitative phase. To do this, it is essential that we think in terms similar to those introduced into chemical science by the methods of Physical Chemistry. We must think in terms of *processes and relations between processes.* The physiology of development is quite different from the physiology of adult life, since the latter is mainly concerned with the regulation of the functions of the body so that they do not depart beyond certain limits from the normal. Developmental Physiology, on the other hand, is concerned, not with constancy, but with change; during development continually new structures and functions are appearing, each phase proceeding to a point at which it resolves itself into a new and qualitatively different phase; and the regulation that exists is concerned with the proper sequence of these phases in such a way that a normal adult is the outcome.

Thus if *Entwicklungsmechanik,* or Developmental Physiology, wishes to become accurate, it must concern itself with the *speed* and the *equilibrium* of processes. Time-relations on the one hand, interaction on the other—these are the two chief points with which it must deal. We have seen that metamorphosis depends upon the time-relations, *inter alia,* of thyroid-differentiation; we have also seen that the inter-relation of thyroid differentiation with other developmental processes has to be considered. This point of view has been introduced into general biology mainly by Goldschmidt's work on consecutive intersexuality. It is, I think, safe to prophesy that Amphibian metamorphosis will provide the most favorable field for the next steps in its cultivation. There are many clinical observations on mammals and man which await elucidation from such a quantitative study of Developmental Physiology: variations in the onset of puberty; pathological sexual precocity; infantilism; progeria; premature senility and so forth.

In conclusion, one or two points may be touched upon which these general considerations help to illuminate. We have seen that it is a fallacy to think of the thyroid as having a specific metamorphosis-producing effect. In the same way, it is a fallacy to think of it as being a specific growth-promoting agent. This idea has gained currency owing to the fact that cretins are permanently stunted in growth, and that early thyroid administration often causes normal growth to be resumed. A physiologist with whom I was conversing recently was much surprised—one could almost say horrified!—on hearing that thyroidectomy did not adversely affect the growth of tadpoles.

The fact of the matter appears to be, as we have seen, that certain tissues grow well at a low level of thyroid concentration, others at a high level.

Among those which appear to need a high level, those composing the human brain are prominent. Many of the stunting effects of cretinism are quite probably secondary, due to the absence of the normal trophic effects of the stunted nervous system; (compare the experiments of Forsterling on similar secondary stunting due to x-ray treatment of the brain region in mammals). In a precisely similar way, the human brain requires a high temperature to work properly; lowering its temperature a few degrees will bring about a failure of consciousness. Similarly, it is so familiar as often to escape notice that a high temperature and consequent general rapidity of metabolism is necessary for development to occur at all in mammals and birds; their development ceases at a temperature still above the optimum for that of Amphibia.

In this connection, it is interesting to note that the relative size of the thyroid is stated to increase progressively in the different classes of Vertebrates, being smallest in fish, and largest in warm-blooded animals. To put it as crudely as possible, "frog-constitution" without thyroid only becomes a tadpole; "man-constitution" without thyroid becomes a cretin. The difference between the two cases is that one is pathological, the other is not. This difference between the requirements of the tissues of tadpoles and those of warm-blooded Vertebrates should not be forgotten when estimating the value of experiments with tadpoles as a means of throwing light on human physiology.

Summary

(1) Amphibian metamorphosis is considered as a transition between two phases in a consecutive dimorphism, and as initiated by a change in internal environment.

(2) The similarity of metamorphosis to the sex-change in protandric and protogynous hermaphrodites and in Goldschmidt's intersexual moths is emphasized; the dimorphism of sex is associated, like that of metamorphosis, with differences in internal or external environment.

(3) The similarity of the breakdown of larval tissues to that of the tissues of lower organisms in dedifferentiation and resorption is pointed out.

(4) Amphibian metamorphosis is probably determined by the relation between thyroid differentiation and the processes involved in the general metabolism of the rest of the larval body.

(5) Through the study of Amphibian metamorphosis, we are enabled to study the processes of differentiation quantitatively as regards their individual rates, and their interaction with each other.

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STERILE ST. REGIS-CUTHBERT HYBRID

FIGURE 5. Both parents belong to the same species, with possibly a slight admixture of "foreign blood," in the Cuthbert. Nevertheless many of the hybrid plants are sterile. This would be expected in a "wide" cross between unlike species, but is quite unusual in crosses between closely related varieties.

A YELLOW-FRUITED "PURPLE-CAP"

FIGURE 6. This yellow-fruited plant is the result of a cross between two pale-fruited varieties of a normally dark-fruited species. All of the plants of this cross were yellow-fruited, vigorous, and showed the peculiar habit of growth of the hybrid purple cap, *Rubus neglectus*.

RASPBERRY BREEDING NOTES

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THERE is growing wild in the vicinity of the Ohio Agricultural Experiment Station at Wooster a yellow-fruited form of the common blackcap, *Rubus occidentalis.* Having in the variety trial-plots of the Station plants of the Golden Queen, which is virtually a yellow-fruited Cuthbert, the writer was curious to see what would be the result of crossing these two yellow-fruited representatives of normally dark-fruited species. Reciprocal crosses were made. The Golden Queen pollen worked well on the Yellow Cap, but the Yellow Cap pollen on the Golden Queen gave few fruits and the resulting seedlings were such as to cast a doubt upon the work. Of the two dozen Yellow Cap × Golden Queen seedlings every one was yellow fruited and all, with one possible exception, showed the extreme vigor and peculiar habit of growth of the hybrid "purple-cap" or *Rubus neglectus.* The fruit was larger than that of the parent Yellow Cap, as well as more juicy, and with the typical *neglectus* flavor. In color it was the faint pinkish yellow of the Golden Queen. This suggests that the yellow color may not be a true color but rather an absence of color or a sort of albinism. It also suggests the possibility of breeding out the unattractive "purple" color of the purple-caps and securing red-fruited or black-fruited *neglectus* varieties by using a yellow-fruited form for one parent in hybridizing, and thus permitting the other to impress its color on the offspring.

Another line of work followed was the crossing of Cuthbert and Ranere (St. Regis) in the hope of securing a seedling with the autumn-bearing habit of the Ranere and the other characters of the Cuthbert. The outstanding result of this work was the high per cent of seedlings with sterile blossoms. In the Ranere × Cuthbert seedlings one in seven was sterile. While in the Cuthbert × Ranere seedlings eleven out of twenty-four bore sterile blooms. Such a high degree of sterility is strange in view of the close relationship of the two, both being *Rubus strigosus,* with the possible admixture of some *idaeus* blood in the Cuthbert. Especially is it to be wondered at when one thinks how readily both *strigosus* and *idaeus* unite with each other as well as with *occidentalis.*

The Human Machine

MAN, THE ANIMAL, *by* W. M. SMALLWOOD, Professor of Comparative Anatomy, Syracuse University. Pp. 223+xiv; $2.50. The Macmillan Company, New York, 1922.

From earliest childhood we are all vitally interested in the working of the machine that is our body. The answer to the question, "What makes it go?" is so complicated that many of us fail ever to understand our own intricacies. Dr. Smallwood's book gives us much valuable and useful information about ourselves in a form that can be easily understood. Starting with the law of biogenesis, he traces the unity of life from amoeba to man and shows how the same fundamental laws apply to all living things. Thirty-two photographic illustrations and many line drawings

add greatly to the charm and interest of the book.

While he takes great pains to make clear man's close kinship to all living things and emphasizes the chemical and physical laws that are the "physical basis of life," the author does not adopt the views of the extreme mechanistic school. In particular one statement deserves consideration by those who feel that the existence of a "physical basis of life" is sufficient to "explain" life: "The biologist starts with life as it now exists, just as the physicist starts with energy and the chemist with atoms on all their infinite complexity. They do not try to *explain* energy and oxygen and carbon."

Nearly half of the book is given up to discussion of heredity or related matters. The final chapter, *Biology and Progress,* deals with the application of what man has learned about life and heredity to every day affairs. Summarizing, the author says: "In this brief sketching of some of the more probable fields of progress which will give a better understanding of man, no revolutionary changes are anticipated, nor is it suggested that fundamental laws will be altered. Progress must rather be in conformity with those principles which clearly indicate that we must recognize the ineradicable influence of heredity and that the right of being well born has a scientific foundation; that good food and a wholesome environment play an important part in well being; . . . and that mankind cannot set aside these basal relations."

Most of the author's views would receive the approval of students of heredity, but before leaving this excellent book, attention should be called to one or two statements that possibly are not altogether clear. In explaining Mendelian inheritance he says: "When the peas of this (first) hybrid generation are planted, the plants are partly tall and partly short, but none are intermediate. In the subsequent breeding of this experiment the short peas give rise to short peas and the tall ones to tall peas," which is a result that would hardly be expected by the scientific breeder.

Certain of his views on evolution might also be questioned by many students in this field. After remarking that artificial breeding has produced no new species, he adds: "This seems to mean that the more than hundreds of thousands of genera and species became fixed before man had thought seriously of questioning their origin. The result is that the life of today is highly specialized and adapted to a given environment. This gives a non-plastic series of forms to deal with, and science has been thus far utterly unable to reconstruct the conditions under which the former changes took place." It is hard to see why the present living forms should be considered any less plastic than their ancestors. Evolution is not something that happened in the past, but a vital, living force today. *The Origin of Species* was published only about half a century ago, and evolution has been studied experimentally for only the last twenty years. True, the problem is not yet solved, but that no progress has been made, few students of evolution would be willing to admit.

HEREDITARY SHORTNESS OF THUMBS

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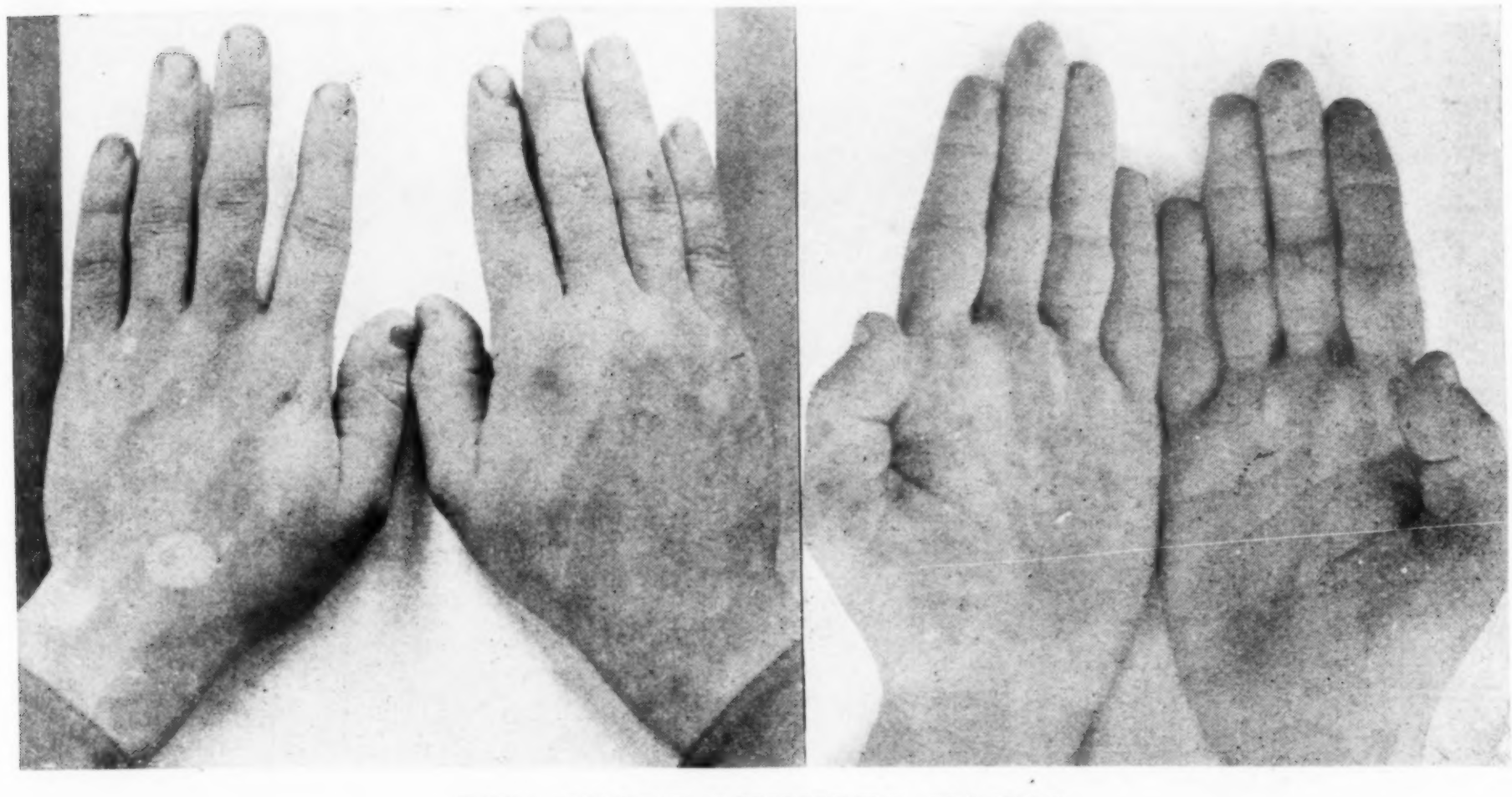


THE SHORT THUMBED HANDS

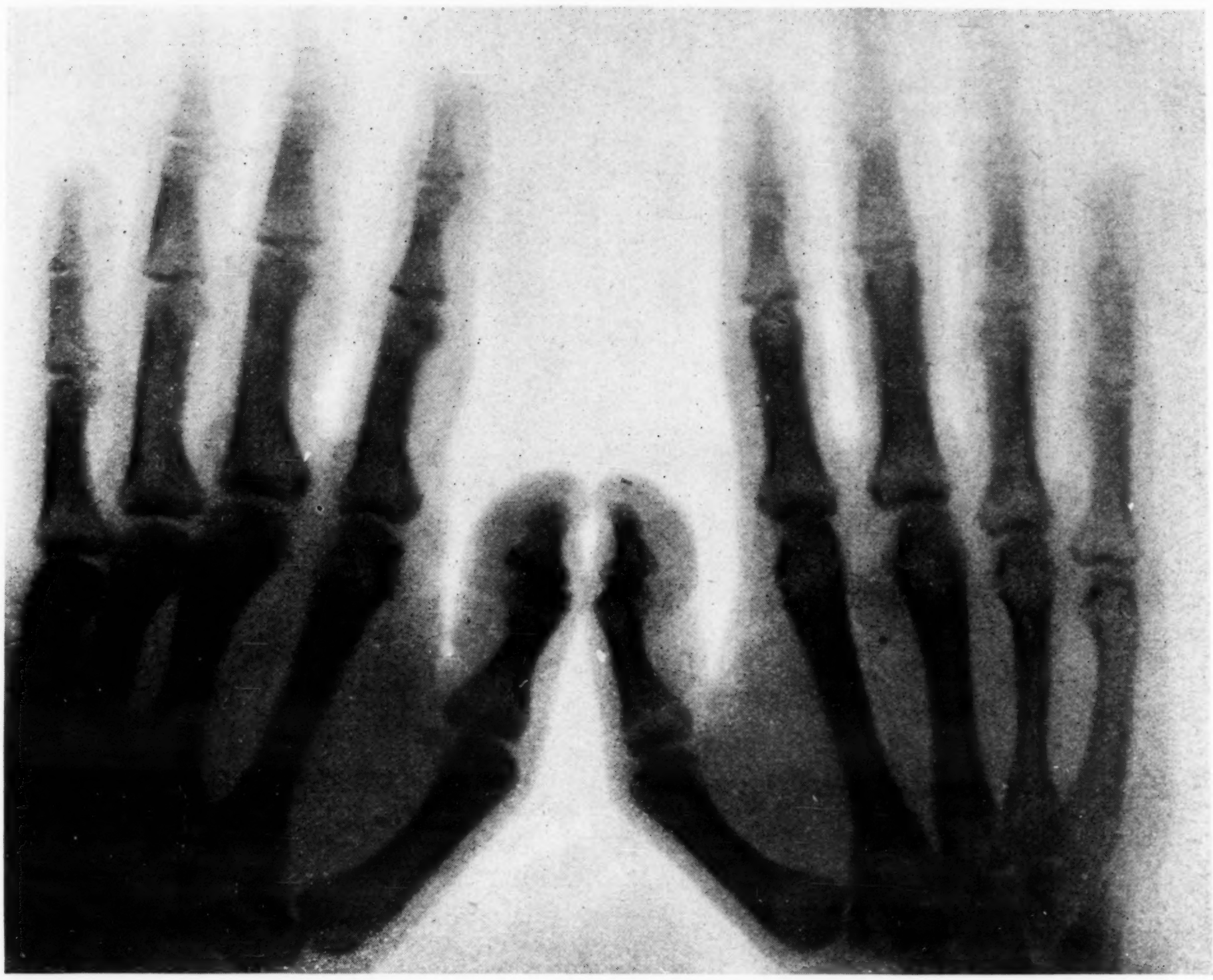
Figure 7. The tip of the normal thumb comes nearly to the first joint of the index finger, but this thumb extends scarcely beyond the knuckle. The thumb-nail is also very short and broad. The inheritance of this trait has been traced for five generations and at least one child of every short thumbed individual had thumbs of this kind. The hands shown above are those of the man designated Abnormal 7 in the article. His hands were taken as a standard in comparing the differences between short thumbed and normal hands. An x-ray photograph of the same pair of hands is shown in Figure 8.

IT has been about ten years since the writer made the first observations upon the abnormality which is described in this paper, namely a human hand in which the thumb is disproportionately short. During these years information has been collected, whenever the opportunity presented itself, by personal observation. Since the abnormal character has been traced through five generations, it is thought feasible to publish all data at present, rather than to withhold it for further information.

One sees, upon external examination, a hand that is long and narrow when compared with the normal; but the most clearly distinguishable characteristic about this hand is that every individual affected manifests a thick, short thumb with a nail that is very broad and short (about three-quarters of an inch in width and five-sixteenths to three-eighths of an inch in length).

To determine the amount of variation in the normal thumb, the writer made outline drawings of palmar views of several hands, consisting of random samples taken from college students and from the normal members of the short-thumbed family. Each sketch was made by placing the hand on a sheet of paper, and with the aid of a pencil outlining the hand by marking the outside of each finger.

[1] Contribution from the Zoological Laboratory of the University of Oklahoma, Second Series, No. 28.



X-RAY OF THE SHORT THUMBED HANDS

FIGURE 8. The long bones of the palm of the hand are termed metacarpals, the three finger bones are the phalanges, the first phalanx being at the base of the finger. While this picture is slightly more reduced than that of the normal hand (Figure 9), it enables direct comparison to be made between the bones of the two hands, as the reduction is such that the metacarpals of the thumbs of the two hands are of exactly the same length.

The result of this observation indicates that on the average the end of the normal thumb coincides with the joint at the union of the first and second phalanx of the index finger. The abnormal members of this family have thumbs the ends of which, on the average, coincide with the joint at the junction of the metacarpal and first phalanx of the index finger. Briefly, the abnormal thumb is shorter than the normal by the length of the first phalanx.

To study this abnormality in greater detail and to determine the internal effects of this mutation, it seemed desirable to have x-ray pictures of the hands of one of these affected individuals. This radiograph was then compared with two radiographs of normal thumbs, as well as with three skeletons. It was thought possible that the shadows of the bones might interfere with the technique of measuring, but it was found that a radiograph is a source of information as accurate as the bones themselves.

A comparative analysis was made with one abnormal (Abnormal 7) and the five above-mentioned normal right hands, by measuring the length of the bones of each digit. Complete data regarding these measurements are given in Table 2. The number of hands measured in all was six pairs,

A NORMAL HAND

FIGURE 9. The comparison between short and normal thumbs was made by taking the average of the measurements of the bones of five normal hands. The metacarpals of the short thumbed hands were found to be longer, and the terminal phalanx of the short thumb much shorter than the corresponding bones in the normal hands. It is this short phalanx of the thumb, and the unusually long metacarpals of the fingers that are inherited.

of these the first five were normal; the sixth measured was a radiograph of Abnormal 7. From a comparison of the abnormal with the five normal pairs, one discovers a difference in the metacarpals, and in the second and third phalanges, but much closer agreement in all six pairs of hands as regards the first phalanx. Because of this approximate agreement it seemed that the essential relations could be brought out better by expressing all measurements as ratios in terms of the first phalanx of the digit in question. These ratios are given on the right of Table 2, under the heading, "Calculated ratios."

To obtain a more direct comparison between the abnormal and normal bones of each digit, the ratios obtained for the five normal cases were added together and an average normal ratio obtained. These averages for the normal bones are compared with the

abnormal in Table 3. The ratios here tabulated show that the metacarpals of the abnormal hands are longer in proportion to their first phalanges than are the average of the metacarpals of the normal hands. The metacarpal of the abnormal thumb is actually about one-seventh longer than the average of the five normal first metacarpals. The last phalanx (Phalanx 2) of the thumb, however, is almost one-half shorter than the corresponding joint of the normal thumb. It is because of this fact that the thumb appears so short when compared with a normal thumb and, moreover, it is this short phalanx which is inherited in this family. It appears also that the second phalanx of each of the digits of the abnormal is relatively shorter than those of the normal. Compensatory regulation occurs in the appearance of the fingers, since the extra length of the metacarpals is balanced partially by the short phalangeal joints. The last phalanx of the abnormal digits bears no definite relation to the last phalanx of the normal, since it is sometimes longer and sometimes shorter in relation to its first phalanx.

THE OLDEST OF THE SHORT THUMBS

FIGURE 10. The woman designated Abnormal 2 is now nearly eighty years old, and remembers well that her mother had short thumbs, for they both had to use especially short needles in sewing. Beyond this it has been impossible to trace the character, but the evidence indicates that for five generations it has been inherited as a Mendelian dominant.

History of the Short-Thumbed Family

The record of these short thumbs, according to the writer's information begins with a woman (Abnormal 1) who has long been dead. Her daughter (Abnormal 2) when 78 years of age, said that she well remembers that her mother had short thumbs on both hands and, moreover, that both she and her mother always used especially short needles in sewing, because long ones would break in their hands. This peculiarity is correlated with shortness of thumbs.

The following is a brief record of the occurrence of the character in this family:

Abnormal 1, a woman, married a normal man. She had two abnormal children (Nos. 2 and 3), two normals, and four who died as infants.

Abnormal 2, sister of Abnormal 3, married a man with normal hands. Her offspring were two abnormals (Nos. 4 and 5), five normals, and three who died in infancy.

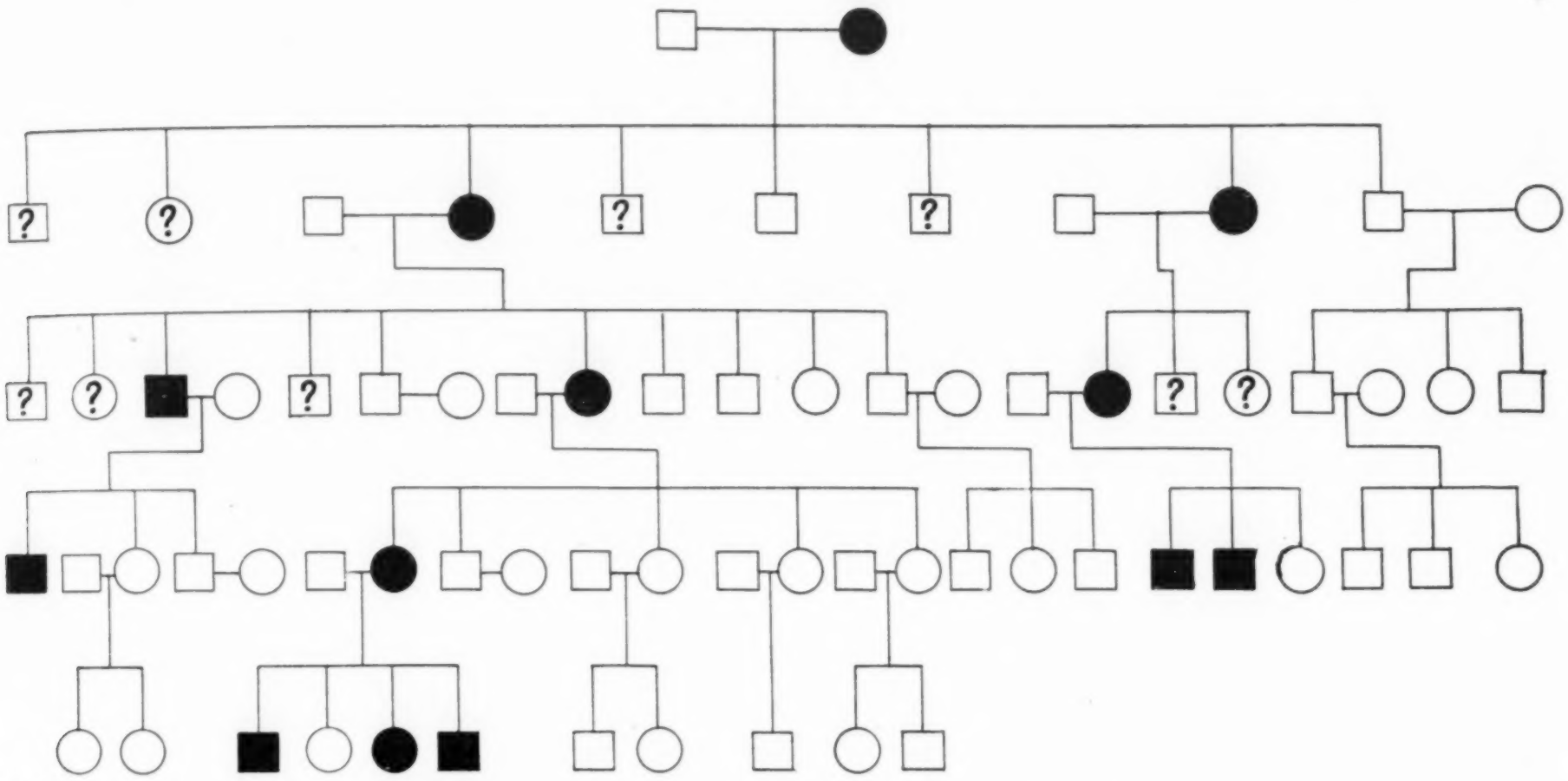
Abnormal 3, daughter of 1, was married to a normal man. They had one abnormal daughter (No. 6) and two children who died as infants.

Abnormal 4, son of 2, married a normal woman, and they had one abnormal child (No. 7), and two other children who were normal.

Abnormal 5, daughter of 2, married a normal man. This pair produced one abnormal daughter (No. 8) and four normal children.

Abnormal 6, daughter of 3, married a normal man. She had two abnormal sons (Nos. 9 and 10) and one normal daughter.

Abnormal 7 is unmarried.



INHERITED FOR FIVE GENERATIONS

FIGURE 11. Circles represent women, squares, men. Short thumbed individuals are indicated by solid black; a question mark shows an individual who died in infancy, about whose thumbs nothing is known. It is evident from the chart that the character is as likely to appear in one sex as in the other. A study was also made of the members of the family who had normal hands, and among their descendents not a single individual having short thumbs was found.

Abnormal 8, daughter of 5, married a normal man. Their offspring consisted of three abnormals (Nos. 11, 12 and 13), son, daughter, and son, respectively, and one normal daughter.

Abnormals 9, 10, 11, 12 and 13 are not old enough to be married.

To summarize the appearance of abnormals with reference to generations: the first generation begins with No. 1 and in the second generation Nos. 2 and 3 appeared. Abnormals 4, 5, and 6 were in the third generation, and in the fourth generation were Nos. 7, 8, 9, and 10. Lastly, Abnormals 11, 12, and 13 appeared in the fifth generation. Thus for five consecutive generations the trait has appeared.

The writer also obtained complete pedigrees of normals mated with normals in this family, but to give the complete data and family histories for such normals would require too much space and possibly be of little value. The results of this investigation can be summarized by stating that whenever normal members of the family married other normal individuals there were no abnormal children. Every individual with an abnormal hand had one abnormal parent. As the other parent, in every case, was normal, all of the abnormal individuals must have been heterozygous.

Discussion

It seems that this character is the result of a mutation which appeared more than five generations ago. If the abnormality in this family is a part of the normal variation in length of thumbs that is to be expected, it is true that some short-thumbed individuals should be discovered among the hundreds of people examined. It further appears that shortness of thumbs is a mutation because its range of variation differs from the normal.

The results given in Table 1 indicate that this character is a Mendelian dominant, the normal being recessive. If we represent the homozygous dominant trait by (AA) and the recessive, normal, by (aa), it is apparent that all offspring from the modification

should give a 1:1 ratio, because in every instance an abnormal individual was mated with a normal. Thus every abnormal person was heterozygous (Aa) and every normal homozygous (aa).

Table 1 further shows that matings of heterozygous (Aa) individuals with normal persons (aa) gave as a total 9 who died in infancy, 12 abnormal children and 15 normal. Of those who died as infants some at least might have had the abnormal character linked with the mortality; however, if this interpretation is not correct, the law of probability would lead us to expect that half of those individuals who died in infancy would be normal and the others abnormal. It therefore seems desirable to omit those who died as infants from any further consideration.

Following this suggestion the author tabulated in Table 4 the Observed Data, Observed Ratio, Theoretical Ratio, and Probable Error. The conclusion is that the observed ratio is a good fit because the number of normals and abnormals give a 1:1 ratio, which proves that in this family all abnormals are heterozygous, while the normals are homozygous recessives.

Other Abnormalities of the Skeleton

The many human pedigrees which have been published show that the majority of hereditary abnormalities found in the skeleton are inherited as Mendelian dominants. Davenport[1] enumerates several in this connection. One of the most common is polydactylism, by which is meant supernumerary fingers and toes; another abnormality is syndactylism, which means that the bones and tissues of two or more fingers are fused or webbed into one mass; while another is brachydactylism, which may be defined as an abnormality having digits and limbs exceedingly short. Cushing[2] has added another to this list of dominants, symphalangism, which means that the proximal phalangeal joints become fused. Another dominant is that of achondroplasism, described by Davenport[1] as a condition in man characterized by abnormally short limbs, as is osteopsathrosis or hereditary fragility of bones as shown by Davenport and Conard[3]. Lastly, hereditary shortness of thumbs as described in this paper is another abnormality of the skeleton which is dominant.

Summary

The character is neither sex-limited nor sex-linked, because it is found in both sexes, and is not transmitted from a man through his daughters to one-half of their sons. The evidence presented indicates that it is an autosomal Mendelian dominant.

TABLE 1. *The character of the offspring of the eight abnormal parents. The matings were in every instance between an abnormal (Aa) and a normal (aa).*

Parents	Progeny		
Abnormal No.	Died in infancy	Adults Abnormal	Adults Normal
No. 1.....	4	2	2
No. 2.....	3	2	5
No. 3.....	2	1	0
No. 4.....	0	1	2
No. 5.....	0	1	4
No. 6.....	0	2	1
No. 8.....	0	3	1
Totals....	9	12	15

[1] DAVENPORT, CHARLES B. *Heredity in Relation to Eugenics.* 298 pps. Henry Holt and Company, New York. 1911.

[2] CUSHING, HARVEY. Hereditary Anchylosis of the Proximal Phalangeal Joints (Symphalangism). *Genetics* I: 90-107. 1916.

[3] DAVENPORT, CHARLES B. and H. S. CONARD. Hereditary Fragility of Bone (Fragility Osseus, Osteopsathyrosis). *Eugenics Record Office Bulletin* 14. 31 pps. 1915.

TABLE 2. *Length of the bones of six right hands, five normal and one abnormal (Abnormal 7). The lengths are given in millimeters in columns two to five. The ratio of each measurement to the length of the first phalanx of the digit in question is given in columns six to nine.*

Normals	Observed Data				Calculated Ratios			
	Meta-carpel	Phalanges 1	2	3	Meta-carpel	Phalanges 1	2	3
1 (X-ray)								
Digit 1	46.5	31.5	24.5	....	1.476	1	.777	....
" 2	70.5	40.5	24.0	19.0	1.753	1	.592	.469
" 3	70.5	46.5	29.0	19.5	1.516	1	.623	.419
" 4	64.0	43.5	28.0	20.0	1.471	1	.643	.459
" 5	56.0	34.0	20.0	17.0	1.647	1	.588	.500
2 (X-ray)								
Digit 1	49.0	34.8	25.0	....	1.410	1	.719	....
" 2	74.0	43.0	25.5	18.0	1.721	1	.593	.419
" 3	71.0	47.5	31.0	19.0	1.505	1	.652	.400
" 4	66.0	45.0	29.0	20.0	1.467	1	.644	.444
" 5	61.0	37.0	22.0	18.5	1.648	1	.592	.500
1 (Skeleton)								
Digit 1	43.0	30.0	22.0	....	1.433	1	.733	....
" 2	69.0	39.0	23.0	16.0	1.769	1	.587	.415
" 3	65.0	43.0	28.0	17.5	1.511	1	.651	.407
" 4	60.0	41.0	27.0	18.0	1.463	1	.658	.439
" 5	51.0	31.0	18.5	16.0	1.645	1	.596	.516
2 (Skeleton)								
Digit 1	48.0	33.0	23.5	....	1.484	1	.712	....
" 2	72.0	42.0	25.0	17.0	1.714	1	.595	.405
" 3	69.5	46.0	30.0	18.5	1.510	1	.652	.402
" 4	64.0	43.0	28.0	18.0	1.488	1	.651	.419
" 5	54.0	33.0	20.0	16.5	1.637	1	.606	.500
3 (Skeleton)								
Digit 1	37.5	26.0	20.0	....	1.442	1	.769	....
" 2	58.0	34.0	19.5	15.0	1.706	1	.573	.470
" 3	55.5	37.0	23.0	15.0	1.500	1	.649	.405
" 4	51.0	35.0	23.0	15.0	1.457	1	.657	.429
" 5	43.5	26.5	16.0	15.0	1.642	1	.603	.527
X-ray Abnormality 7								
Digit 1	53.0	32.0	13.0	....	1.637	1	.406	....
" 2	81.0	41.0	22.0	17.0	1.931	1	.536	.414
" 3	76.0	50.0	26.0	21.0	1.520	1	.520	.420
" 4	65.0	44.0	28.0	21.0	1.477	1	.637	.477
" 5	60.0	35.0	19.0	18.0	1.711	1	.542	.514
	....	....	....	....	....	..	....	....

TABLE 3. *A comparison of the measurements of an abnormal hand (No. 7) with the average of those from five normal hands.*

Digit	Hand	Metacarpel	Phalanx 1	Phalanx 2	Phalanx 3
1	Normal Av.....	1.461	1	.742	....
	Abnormal	1.637	1	.406	....
2	Normal Av.....	1.732	1	.592	.435
	Abnormal	1.981	1	.536	.414
3	Normal Av.....	1.508	1	.645	.406
	Abnormal	1.520	1	.520	.420
4	Normal Av.....	1.469	1	.650	.438
	Abnormal	1.477	1	.637	.477
5	Normal Av.....	1.643	1	.595	.500
	Abnormal	1.711	1	.542	.514

TABLE 4. *Ratio of normal to abnormal individuals in the short-thumbed family.*

Trait	Observed Data	Observed Ratio	Theoretical Ratio	Probable Error
Abnormal	12	.8889	1	0.129
Normal	15	1.1111	1	0.129
Totals.....	27	2.0000	?	

Social and Biological Heredity

SOCIAL CHANGE, by WILLIAM FIELDING OGBURN, Professor of Sociology at Barnard College. Price $1.50. B. W. Huebsch, New York. 1922.

A careful discrimination between biological and cultural changes characterizes this book. Professor Ogburn is himself convinced and convinces his readers that the failure to make such discrimination in the past has been the cause of much confused and faulty thinking. Why is there such a thing as social progress at all? Why new cultures, new inventions, new acquirements? Is it due to the evolutionary development of human biologic structure or is it due to other causes—cultural influences under which or through which man is called to pass? Such questions are intimately discussed and the result is illuminative.

We are especially impressed by an illustrative item by which the author explained his thesis as to the fact of a cultural progress in the race wholly separate from any biologic change in individuals. It was a list carefully compiled of some one hundred and fifty instances of duplicate inventions —of inventions made at the same time by two or more students or experimentors. The conviction was inescapable that inventions come, inevitably, at certain stages of culture, not because there happened a single individual of greater mental capacity, but because social conditions were at a stage when such inventions were both needed and were possible on the basis of preceding discoveries. Then, evidently, they came, and to more than one mind. It has been social progress rather than progress of individual gifts that has given man his great discoveries.

The two sections of the book, the first on the why and how of social change, and the second on the why and how of the drag or slow process of that change, are each of them interesting both in themselves and in the suggestive illustrations drawn from studies of contemporary facts or timely problems. —R. E. C.

COLOR INHERITANCE IN FOWLS

The Genetic Relationship of the Black, Buff and Columbia Colorations in the Domestic Fowl

L. C. DUNN
Storrs Agricultural Experiment Station[1]

THE VAST array of variations in color, pattern and form of feathers and other parts, which is observed in the domestic fowl, has made it enticing material for many students of variation and heredity. A great deal of information on the inheritance of many of the characters which distinguish the various breeds has been accumulated since Bateson first took up the study shortly before the rediscovery and application of the Mendelian method of investigation. A large part of the field of poultry genetics is still, however, unexplored country. We are still ignorant concerning the inheritance and relationships of some of the most obvious traits which differentiate our common varieties.

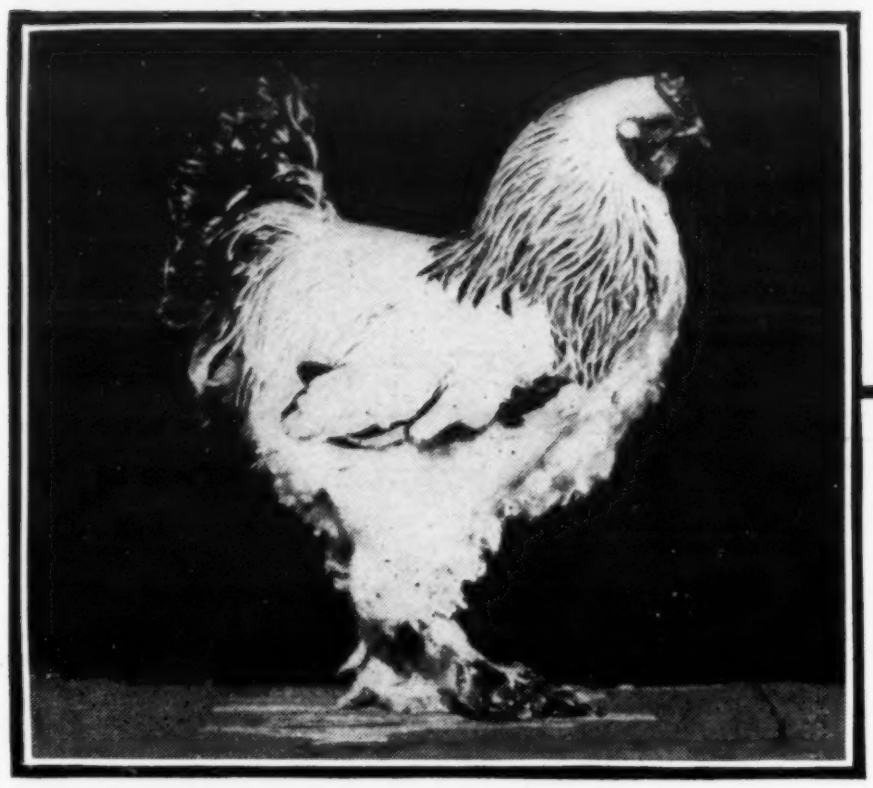
The present article describes the results of some experiments which were designed originally to furnish data on a certain class of heritable characters in fowls, namely those which are transmitted in the peculiar fashion known as sex-linked. Several such characters are known in fowls, but concerning the relations between them, or how their expression is altered by other characters we have but little information.

Columbian and Buff Color-Factors

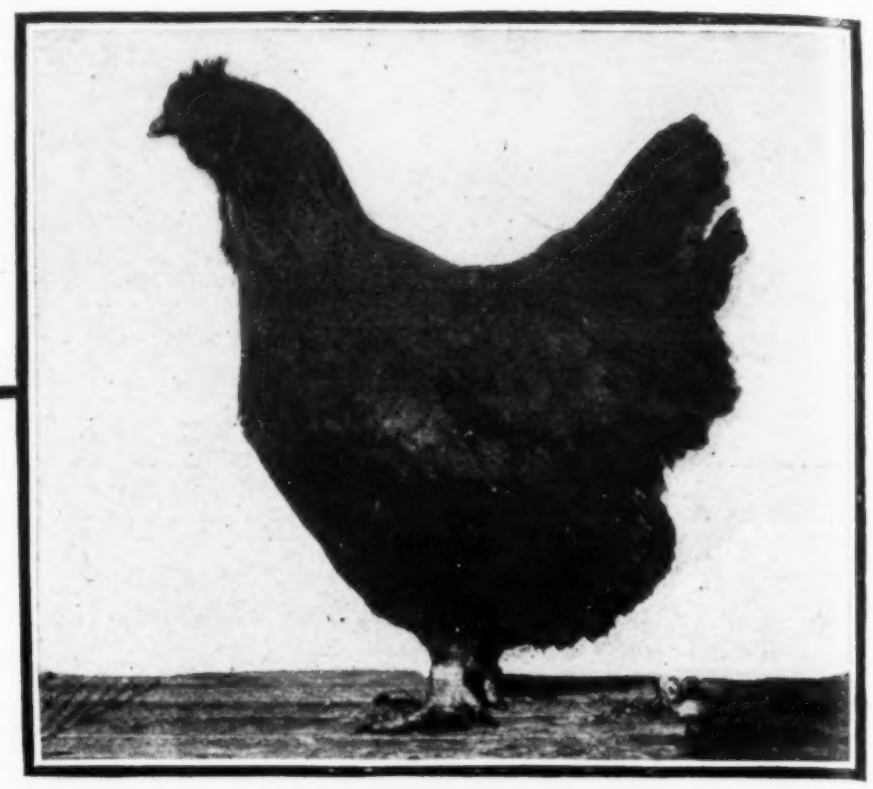
The author's first experiments, which have been partially reported elsewhere[2], consisted in a study of the relationships between two well-known color patterns which exist in several breeds of fowls. One of these colorations is known as Buff (Figs. 13 and 14), in which the whole plumage of both sexes is an even shade of buff, with an occasional and generally unnoticeable trace of black in the tail feathers, and more rarely in the wings. This coloration is a varietal characteristic of Buff Plymouth Rocks, Buff Orpingtons, Buff Leghorns, and others. The other type used was Columbian (Figs. 12 and 13), a pattern consisting of clear white surface color in all of the plumage except the primary or flight feathers of the wings, the hackle or upper neck feathers, and the tail feathers which in typical Columbian fowls are marked with black. This pattern occurs in Light Brahmas, Columbian Wyandottes, Columbia Leghorns and others. It had been established by Sturtevant[3] that at least one sex-linked gene was concerned in the production of the patterns of Columbian Wyandottes.

Reciprocal crosses were made between standard bred Light Brahmas and Buff Orpingtons. The first generation males from the reciprocal crosses were alike. They were Columbian pattern birds (Figs. 13 and 14) with clear white body plumage, but with less black in the wings, tails, and hackles than appeared in the Columbian parents. The first generation females (Fig. 13) sired by the Columbian male were likewise of the Columbian type with reduced black. The first generation females out of the cross of Columbian female by buff male were buff in color (Fig. 13), but like the first generation Columbian chicks they developed black pigment in wings, tails and hackles.

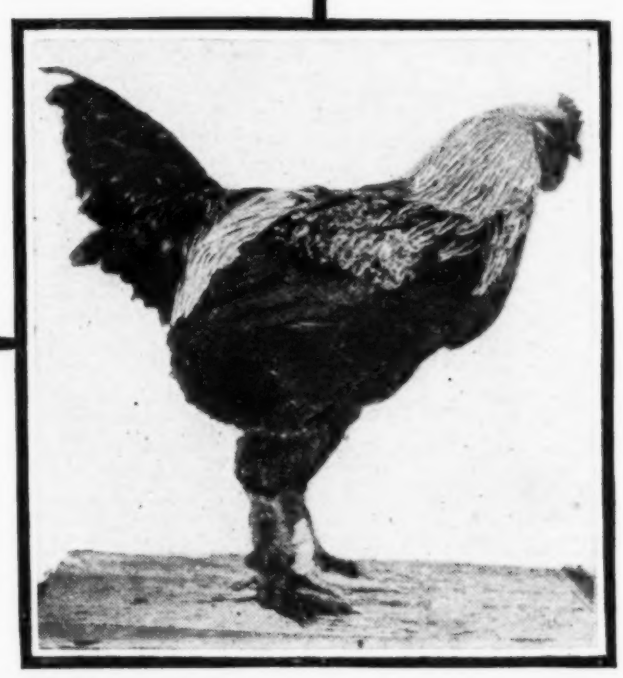
[1] Contributions in Genetics No. 17.
[2] DUNN, L. C. *American Naturalist*, LVI:242-255. 1922.
[3] STURTEVANT, A. H. *Journal of Experimental Zoology*, XII:499-518. 1912.

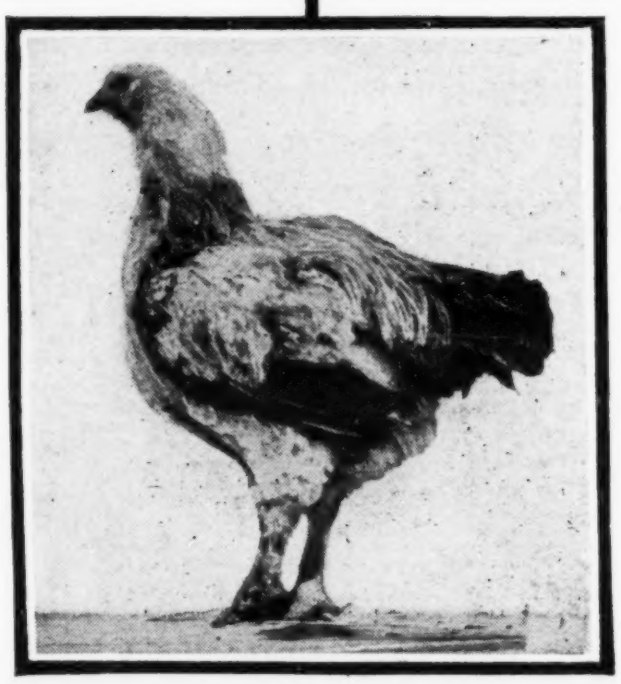


Columbian Male

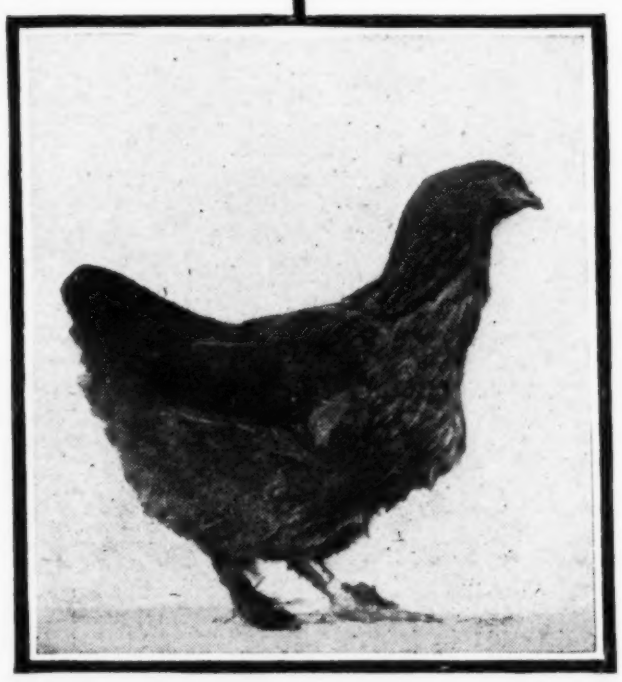


Black Female





Duckwing Male



Birchen Female

Columbian Male

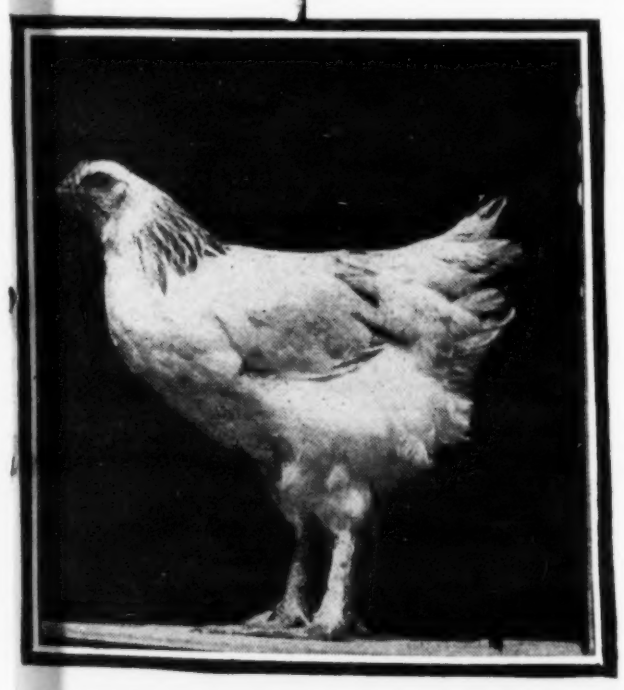
CHART SHOWING COLOR INHERITANCE IN CROSS OF BLACK BY C

FIGURE 12. In the first generation the males are of the Duckwing type, the females of the Birchen with Columbian female, three types of plumage color are encountered: Duckwing males and Birchen fe always females. In the reciprocal cross of black male by Columbian female all males were of the Duckw father. Thus in this cross is found the same type of sex-linked inheritance found in the Buff-Columbian cr

The numbers of chicks produced by these crosses are given in Table 1. It is at once apparent that as regards the difference between buff and white ground color the reciprocal crosses give different results. Columbian is transmitted by the Light Brahma male to both sons and daughters and is almost completely dominant. Columbian females, however, transmit the character only to their sons; their daughters are buff like the father. The first generation Columbian females when backcrossed to pure buff males produced approximately equal numbers of buff and Columbian chicks. All of the buffs were females and all of the Columbians were males. The first generation Columbian males bred to buff females, on the other hand, produced equal numbers of buff males and females and Columbian males and females. The buffs extracted from these backcrosses when bred *inter-se* produced only buff chicks of both sexes. These results indicate that the white Columbian coloration is due to a single dominant sex-linked gene, (called Silver), the recessive allelomorph of which is buff. The gene for silver when present singly in the zygote, apparently prevents the development of buff pigment in the plumage, as Sturtevant and Punnett have concluded from other cases.

The other heredity (as far as it concerns plumage color) of the Columbians and buffs used by us is apparently very similar, with the exception that these two varieties differed also in the extent to which black was developed in the feathers of the wing, hackle and tail. The Columbians had much black in these parts; the buffs had almost none, while the hybrids had an intermediate amount. Later generations showed that factors governing the amount of black pigment were transmitted independently of sex and of the ground color of the plumage. These "darkening" modifiers were probably numerous in the Columbian and few in the pure buff type. (See Fig. 15 showing variations in amount of black in the wings and tails of both Columbian and buff types.)

From these experiments it appeared that the Columbian and buff colorations differed in one gene determining the presence or absence of buff in the plumage, and also represented two stages in the development of black in the plumage. The localization of black was similar in the two varieties, being restricted in each type to the feathers of the wing, hackle and tail.



Columbian Female

Buff Female

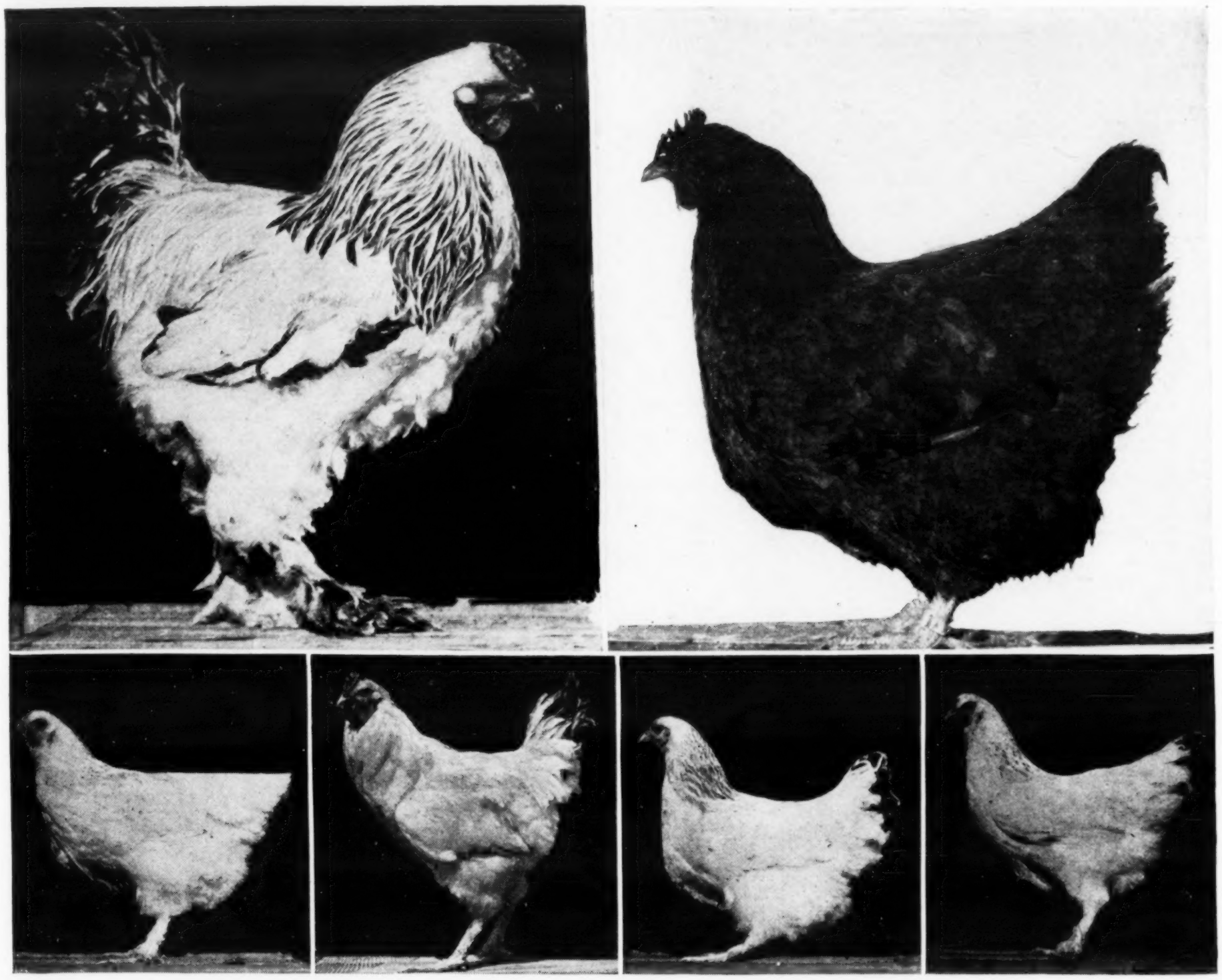
BLACK BY COLUMBIAN AND BACKCROSS

of the Erchen. In the backcross of the first generation Duckwing male nd Birchen females, Columbian males and females, and a new type, buff, of the Duckwing type, but the females were unmarked black like their f-Columbian cross (Figures 13 and 14).

Columbian and Black

Further experiments were undertaken to study the expression of the silver gene when introduced into fowls in which much black pigment was present, as in self-black varieties. We hoped also to learn something of the genetic constitution of the blacks with regard to the presence or absence of the silver gene and to study the transmission of the pattern in which black is restricted to the wings and tail.

Reciprocal crosses were made between Light Brahmas as the Columbian pattern parents, and



SEX LINKED INHERITANCE IN BIRDS

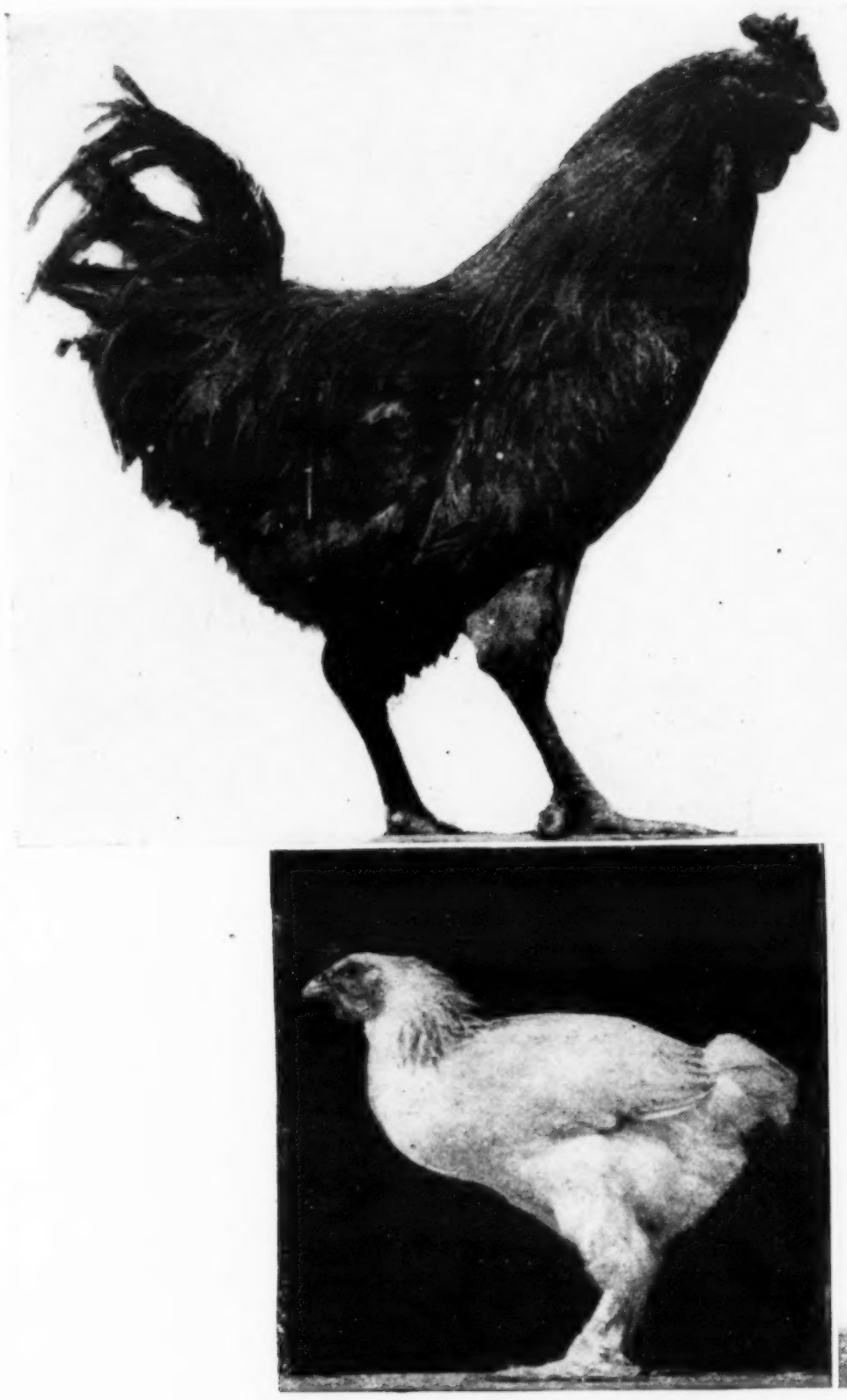
FIGURE 13. In the cross between Columbian male and Buff female, both sexes of the first generation are Columbian. In the reciprocal cross this is not the case, only the males are Columbian, the females being buff like their father. Further breeding experiments prove these females to be entirely free from the Columbian color factor, and to be genetically pure buffs. This type of sex-linked inheritance, found in moths, butterflies, and birds, is known technically as "WZ" inheritance to distinguish it from the "XY" type of inheritance found in man, and in the fruit fly, where it has been most intensively studied.

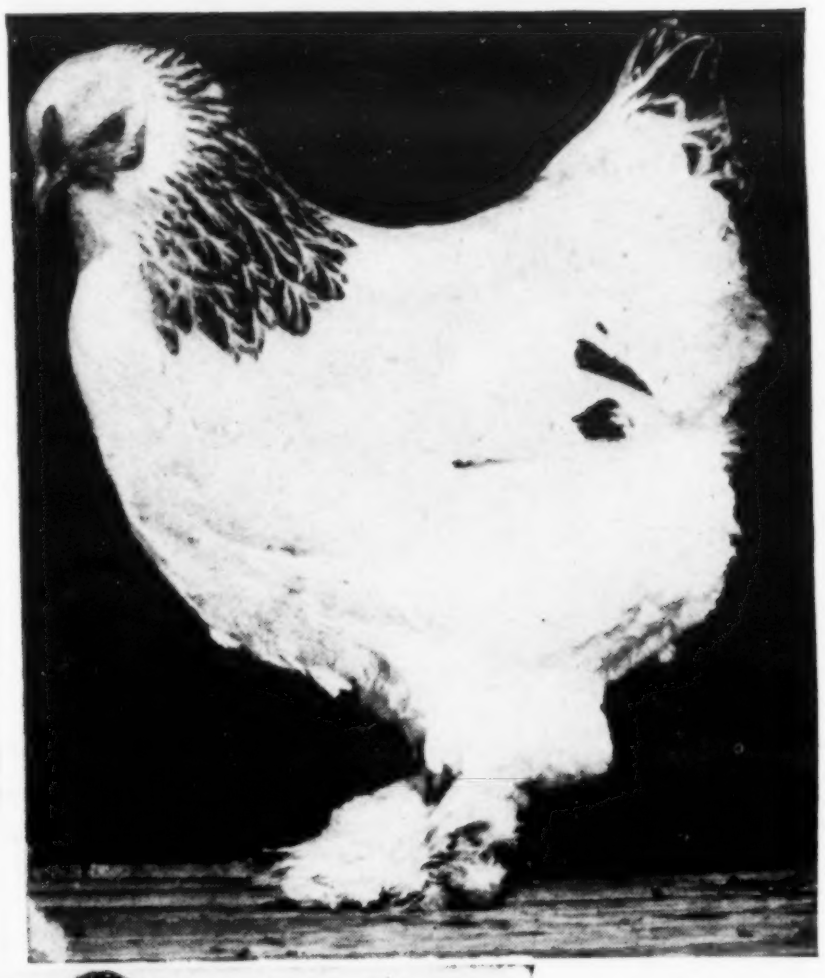
several self-black fowls, chiefly pure bred Black Orpingtons (Fig. 12), although a few self-blacks extracted from a previous cross of Light Brahma by White Leghorn were included. In the first generation the reciprocal crosses yielded dissimilar results. Columbian male by black female produced all black chicks (see Table 2). As adults the males and females from this cross were quite similar aside from secondary sexual differences in pattern.[4] They were black with much white lacing appearing in the hackles, saddles, and wing bows of the males (Fig. 12). These males have been classified as Silver Duckwings, since they resemble that plumage type. The females were likewise black with white lacing on the feathers of head, neck and breast, as in the Birchen pattern (Fig. 12). The appearance of sexual dimorphism in

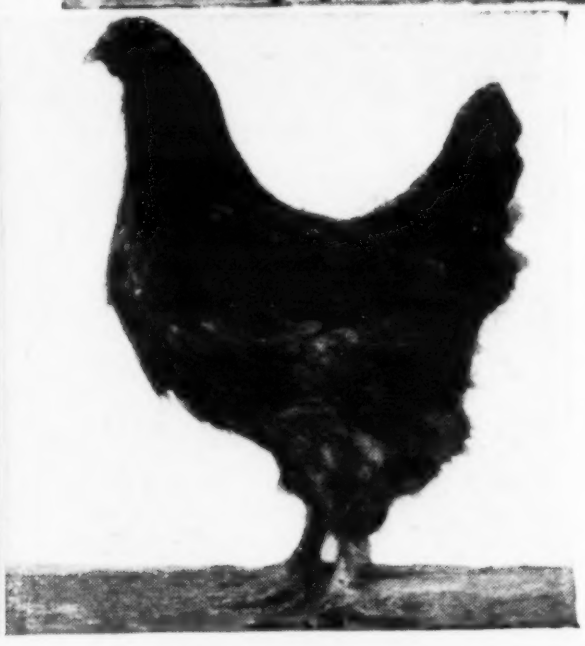
[4] All of the females from this cross died before the adult plumage was fully developed. It is assumed that their adult pattern would have been similar to that of the black daughters of F1 Black ♀ × Columbian ♂ (cross 7 Table 2).

Buff Male

Columbian Female







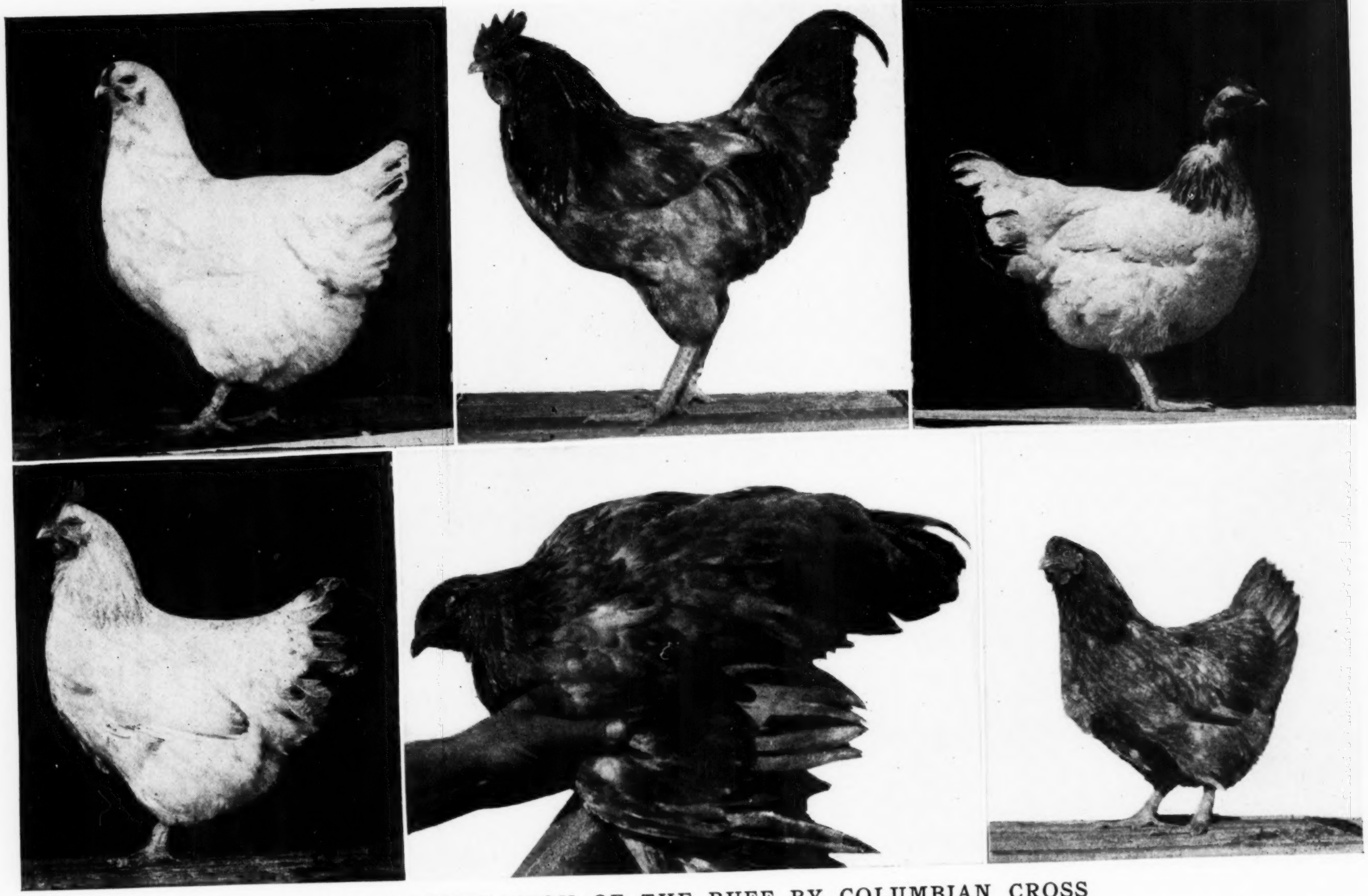
Columbian Male **Buff Female**

THE RECIPROCAL CROSS

FIGURE 14. When the male is buff and the female Columbian all females of the first generation are buff, while the males are Columbian like their mother. This mode of sex-linked inheritance is explained by assuming that there are two distinct sex-determiners located in the W-chromosome and the Z-chromosome respectively. The W-chromosome has not been shown to carry any other factors than those determining sex. Two Z-chromosomes produce a male, a W- and a Z-chromosome produce a female. That is, all individuals that carry a W-chromosome are females. Therefore the W-chromosome is inherited in the maternal line only. The other sex-determiner must come from the male parent, carrying with it his typical color factor. Thus even though buff is recessive to Columbian, all females of the first generation of this cross are buff, because that is the only color determiner present in the first generation females.

the offspring of this cross was interesting since in both parent varieties the males and females are alike in color and pattern.

The reciprocal cross of Columbian female by black male produced likewise all black chicks. As adults the males were similar to the sons of the first cross described, i. e., black with white in hackle, bow, and saddle in a pattern approximating that of the Dark Brahma or Silver Duckwing. The females from this cross were self black. One of them showed a few red-bordered feathers under the lower jaw. There was no appearance of silvering in the plumage nor any development of pattern.



SECOND GENERATION OF THE BUFF BY COLUMBIAN CROSS

FIGURE 15. The amount of black pigment varies greatly in the second generation. Further experiments showed that the factors producing these black markings are inherited independently of sex, and of the ground-color of the plumage. In the Columbian and buff varieties the distribution of black is limited to wings, hackle, and tail.

The first generation Duckwing males were backcrossed with Columbian females (Fig. 12) and were also tested by crossing with buff females. The results are given in Table 2, crosses 4 and 5. By the Columbian females these males produced equal numbers of black and non-black chicks (40:39); while of the non-black chicks thirty-three were Columbian and six were buff. Of the buffs four lived and proved to be females, while two which died young were dissected and also found to be females. Both sexes were present in the black and Columbian classes. By the buff females the first generation males produced also approximately equal numbers of black and non-black chicks (19:22). Of the non-black chicks approximately half were Columbian and half were buff. The sexes were equally represented in all classes.

It is plain from these facts that a single factor affecting the development of black pigment differentiates the black from the Columbian coloration. The factor for self-black or extension is dominant over its recessive allelomorph in the Columbian type in which black develops to a limited extent in the wing, hackle, and tail feathers. Segregation takes place in the gametes of the first generation male, and when crossed with a non-extended type, black (extended) and non-black (restricted) chicks appear in a normal monohybrid ratio. However, an additional factorial difference between black and Columbian is necessary to explain the dissimilarity in the adult patterns of the hybrids from reciprocal crosses, and the appearance of a new type, *buff*, when the hybrid males are crossed with the Columbian parent. This difference is apparently the same as that which distinguishes buffs from Columbians. The Columbian males transmit the gene for silver or inhibition of buff to both sons and daughters and even in the presence of extended black this gene is able to express itself in the silvering which appears in both sexes from this cross. The Columbian female transmits it (as we have found above) only to her sons; and these in the crosses with black are silvered in the Duckwing pattern; while her daughters never receive it and are self-black like their father. Moreover, when the first generation Duckwing males are bred to Columbian females we should expect that a certain number of offspring should receive neither silvering nor extension. Since the Columbian female transmits silvering to all sons, but never to daughters, while the first generation Duckwing male transmits it to half of his sons and half of his daughters we should expect that the only individuals not receiving silver from this source should be females. It was found that all buffs resulting from this cross were females and this is undoubtedly the double recessive class showing neither extension nor silvering. The genotypes of parents and the numbers of progeny produced on these assumptions should be as follows:

Let E^m = Extension of black to all parts of plumage.

Let e^m = Restriction of black to wings, tail, etc. (Buff or Columbian.)

Let S = Silvered (Columbian, Duckwing, etc.).

Let s = Not silvered (Buff).

— denotes the W chromosome of the female which has not yet been found to carry any factors.

	Black ♀ E^mE^ms—	×	Columbian ♂ e^me^mSS			
	Columbian ♀ × Duckwing ♂					Birchen ♀
Genotypes	e^me^mS—	E^me^mSs				e^me^mS—
	E^me^mSS	E^me^mS—	e^me^mSS	E^me^mS—		e^me^ms—
	E^me^mSs	E^me^ms—	e^me^mSs			
Adult Colors:	Duckwing ♂	Birchen ♀	Columbian ♂	Columbian ♀		Buff ♀
Down Colors:	Black		Columbian			Buff
Ratio:	4		3			1

A photographic chart showing these crosses given in Figure 12.

The number of chicks expected from this cross on the above assumption compared with the number obtained is given below:

	Black ♂ & ♀	Columbian ♂ & ♀	Buff ♀
Obtained.....	40	33	6
Expected.....	39	30	10

The agreement of the actual results with those expected is good, if one excepts a slight deficiency of buffs and a slight excess of Columbians. With the small numbers involved these departures are not serious.

When the first generation Duckwing male is crossed with buff (double recessive) females equal numbers of all classes of chicks should appear. The results compared with this expectation follow:

	Black ♂ & ♀	Columbian ♂ & ♀	Buff ♀
Obtained.....	19	12	10
Expected.....	20	10	10

The first generation black females (from Columbian ♀ x black ♂) were crossed with Columbian and with buff males. On our hypothesis they should be heterozygous in extension and should not transmit the gene for silver. The results are given in Table 2, crosses 7 and 8. By a Columbian male they produced equal numbers of black and Columbian chicks of both sexes; (15:14) by a buff male they produced equal numbers of black and buff chicks of both sexes (16:13):

Finally, the first generation Birchen females were tested by crossing with Columbian and with buff males (Table 2, crosses 2 and 3). By hypothesis they should transmit extension to half their progeny and silvering to their sons only. All daughters should be buff or black carrying buff. The cross with the buff male is here the critical test.

From this cross resulted the following:

	Black (silv'd)	Black (non-silv'd)		Columbian	Buff	
	♂	♀	sex?	sex?	♀	sex?
Obtained	3	2	2	2	4	2
Expected	3	4		4 ♂	4	

No exceptions to expectation were found and the agreement is as good as could be expected with such small numbers.

Considering all of the crosses together, it is found that all support the hypothesis proposed, as far as down color of chicks is concerned. The cross of extended black × restricted gave in the first generation thirty-two extended. The backcross of the first hybrid generation with restricted (buff or Columbian) gave ninety-nine extended and ninety-eight restricted—equality expected. Extended black appeared to be completely dominant to restriction and completely epistatic to silver in the down pattern. The segregation of silver and buff must then be measured in the restricted classes of chicks and here the crosses of all heterozygous Columbians bred *inter-se* or crossed with buff produced a total of forty-seven Columbian and twenty-two buff, as compared with forty-four Columbian and twenty-five buff expected. Silver in all cases segregated as a sex-linked character dominant over buff.

Due to a high mortality from an epidemic disease, many of the backcross chicks recorded did not live to develop adult plumage. Those which did survive are recorded under "adult colors" in Table 2. All of the black chicks as adults developed plumage in which black was extended to other parts of the plumage in addition to wings, tails, and hackles, while the buff and Columbian chicks developed adult plumage in which black was restricted to wing, tail, and hackle. The amount of black in these parts was variable. In some chicks from the backcross with Columbian, the Columbian pattern segregated in its original form (Fig. 12) both on silver and buff ground colors; while some were ob-

served with as little black in these parts as the original buff parents. None was found outside the range of darkness of pure Columbian fowls. The cross with black cannot be said, therefore, to have had any darkening effect on the Columbian pattern.

Among the extended offspring there was considerable variation in the amount of black in the plumage, although there was no overlapping between the extended and restricted classes. The colors found diluting black, or appearing in a pattern on a black ground were either silver (white) or buff (Fig. 12, bottom row), although in some cases, particularly among the males, it was very hard to tell whether the extra color was white or buff. These doubtful cases were birds with extremely light straw or cream markings which were continuously variable with the pure white and buff marked classes. No self (unmarked) blacks were recovered. Such birds were expected from crosses 3, 4, 5 and 8. The fact that no fowls hatched from the backcross with Columbian or with buff would be pure for extension (E^mE^m) might be expected to account for the absence of pure black segregates were it not for the fact that the females from cross 6 Columbian ♀ × Black ♂) are known to have been heterozygous in extension (E^me^ms—) and yet to have developed self black plumage. The paucity of numbers or the contribution of pattern factors by the later buffs and Columbians used may account for the non-appearance of blacks. The present evidence is not critical.

The patterns in which the white or buff pigments appeared on the black ground-color of the extended backcross female chicks were various, although most of them could be referred to the general class of penciling as it appears in the Partridge or Dark Brahma pattern, concentric lines of light color on a dark ground, following roughly the contour of the feather. In pattern the females varied from the Birchen type with light color only on the head, neck and upper breast (Fig. 12) to a light Dark Brahma or Partridge type. In the males the light pigments appeared principally on the feathers of the hackle, saddle, and wing bow, either as lacing, or as a color occupying the whole feather.

Most of the males could be classified as Silver or Buff Duckwings. Here, as in the females, there was evidence of considerable variation in the amount of black pigment present in the body feathers, and it appeared that in addition to a main factor governing the extension of black to all parts there were minor factors regulating the depth of saturation of the black pigment. In the juvenile plumage some males showed evidences of the female type of penciling. This was never present in adult male plumage with the exception of the markings on the breast feathers of some very light males. The Duckwing pattern is the male equivalent of the partridge or penciled pattern in the female and appears in the males of such varieties as the Dark Brahma or Partridge Plymouth Rocks. The absence of pencilling in the males probably constitutes a secondary sexual or sex-limited difference, dependent on the presence of testicular hormone or the absence of an ovarian secretion. Some of the backcross Duckwing males might, therefore, be expected to transmit pencilling. No progeny tests or castration experiments have yet been completed as a test of this supposition.

Concerning the source of the penciling which appeared in the backcross females we have no exact information. It may have been present in the black parents, which lacked the buff or silver pigment needed to fill the pattern; or as is more probable it may have been present in the Columbian parent, but unable to express itself in the absence of the extension factor. Light Brahma (Columbian) fowls are sometimes seen which have more than the usual amount of black pigment in the under-

color of the feathers on the back. This black occasionally "shows through" on the surface and is often found to be arranged in an imperfectly pencilled or mossy pattern.

Summary and Conclusions

The buff and Columbian colorations of fowls differ in one principal gene determining the presence or absence of buff in the plumage and probably in multiple factors determining the amount of black developed in wing, tail, and hackle feathers.

Buff and Columbian differ from black by a gene determining the restriction of black to hackle, tail, and wing. Its dominant allelomorph, which is present in self black, determines the extension of black to all parts of the plumage.

Black fowls are genetically buffs with the extension factor superposed. When the gene for silver is present in a black or "extended" fowl it "shows through" in a pattern determined possibly in part by the residual heredity of the black, or by pattern factors contributed by another variety. The appearance of fowls which have both extension and silver make it seem probable the the Dark Brahma variety will be found to be of the genotype E^mE^mSS.

Although in the present types, black and Columbian, the plumage is alike in both sexes, in the first and later generations sexual dimorphism appeared in the dark (extended) fowls. This may possibly be traced to a recombination of pattern and extension factors, which reacts to the sexual hormones in a manner different from either parental combination.

The origin of the three colorations considered is not certainly known. Genetic and historical evidence indicates that the buff and Columbian colorations may have diverged by a single gene mutation. Extended black varieties probably antedate the restricted types, and it is probable that the latter arose from the former by a mutation in the extension factor.

TABLE I. *Crosses of Buff and Columbian Fowls.*

Cross No.	Generation	Parents	Down Colors of Chicks		Adult Colors and Sex			
			Buff	Columbian	Buff		Columbian	
					♂	♀	♂	♀
1	P_1	Buff ♀ × Columbian ♂	..	37	..	..	9	8
2	BC	F_1 Columbian ♀ × Buff ♂	34	36	..	21	13	..
3	BC F_1	BC Buff ♀ × BC Buff ♂	83	..	17	15	..	..
4	P_1	Columbian ♀ × Buff ♂	14	13	..	8	12	..
5	BC	Buff ♀ × F_1 Columbian	10	13	3	6	6	6

TABLE II. *Crosses of Black and Columbian Fowls.*

Cross No.	Parents	Down Colors of Chicks			Adult Colors and Sex							
					Extended Black				Restricted Black			
		Black	Columbian	Buff	Duckwing ♂ white	Duckwing ♂ buff	Black ♀	Birchen ♀ white	Birchen ♀ buff	Columbian ♂	Columbian ♀	Buff ♂
1	Black ♀ × Columbian ♂	17	..	..	2	..	..	..	..	..	..	..
2	F_1 ♀[a] × Columbian ♂	2	2	..	..	..	..	..	..	..	..	..
3	F_1 ♀[a] × Buff ♂	7	2	6	1	..	..	..	..	..	..	..
4	F_1 ♂ × Columbian ♀	40	33	6	4	..	..	3	3	7	5	..
5	F_1 ♂ × Buff ♀	19	12	10	2	2	..	2	2	1	2	5
6	Columbian ♀ × Black ♂	15	..	..	3	..	6	..	..	..	..	..
7	F_1 Black ♀ ♂ Columbian ♂	15	14	..	5	..	..	3	..	..	..	..
8	F_1 Black ♀ × Buff ♂	16	..	13	..	4	..	..	3	..	..	2

NOTE—The classes "white" and "buff," under Duckwing males and Birchen females, refer to the color of the markings on necks, hackles, and wings.

PARENTHOOD AND RACE CULTURE[1]

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Memphis, Tenn.

WHEN the founders of this republic first set down the tenets upon which they proposed to establish a new state they declared that all men are born free and equal. This may almost be said to be their basic principle, the cornerstone upon which their entire plan of government was founded, and in general it is the principle upon which most of our laws and a considerable part of our social code has been based. We have never—as a nation—seriously questioned the truth of this assertion, nor gone to any trouble to find out whether its application tended to good or evil results. It was the special pride of those who had a hand in the original formation of the civil and social regulations which still govern these United States that no account was made of caste, that family, birth, breeding, played no part in the assignment of honor or prestige, that every citizen had full chance to rise by merit alone and that all prizes could be gained by those who would reach out and take them.

It is only within the memory of practically every person in this room that anyone seriously questioned the natural equality of all races of mankind. Every man was held responsible for his conduct, which must be regulated according to the code most generally acceptable to his fellows; failure to conduct himself according to this code was visited with punishment. It was admitted that some individuals had less opportunity than certain others to learn and understand this code, and a degree of leniency from society was extended to them on that account, but in general it was taken for granted that those whose conduct ran contrary to the best interests of society erred because they were unwilling—not because they were unable—to act in accordance with generally accepted standards of right and morality.

Environment Overemphasized

During the last quarter century especially, there has been a world-wide impulse toward social betterment and race improvement. Many of those who talked most and labored hardest over these movements did not have a very clear idea of just what they were aiming at. The general idea was that even if nature has imposed certain handicaps upon the individual at birth, these impediments can be removed by proper care of the body and intelligent training of the mind, and that any individual so relieved of his congenital deterrents can in turn pass on to his descendants the physical and mental improvements which his environment has made in him, at the same time failing to transmit to them the undesirable qualities with which he was originally equipped. Thus in the course of a few generations even a heavily handicapped individual might exhibit progeny free from all taint. Of course it was recognized that this was an ideal, not likely to be immediately attained, but it was not doubted that it was at least theoretically possible. It is on this assumption that most of our present system of charities and correction is based. Where the most glaring congenital inequalities have presented themselves—as in the case of the negro—we have endeavored to level them by federal statute, believing that the new doctrine that no man should suffer degradation because

[1] Read before the Memphis Chapter of *The Egyptians,* April 11, 1922.

of race, color, or previous condition of servitude, could completely obliterate the old dictum that the leopard cannot change his spots, nor the Ethiopian his skin.

Recently, however, certain students and investigators began to doubt the possibility of the "transmission of acquired characteristics" which is the scientific statement of the assumption which we have just been considering. As far back as 1869 there had been published in England a book by Francis Galton concerning the Heredity of Genius. This book attracted very little attention at the time it was published, probably because a near relative of Galton's—Charles Darwin by name—had turned scientific attention into other channels and aroused discussion of the Descent of Man, the Survival of the Fittest, and other lines of thought which laid special emphasis upon the effect of environment upon the individual and the race. A new edition of Galton's book was published in 1914, and in the forty-five years which elapsed between the appearance of these two editions has grown up what we now term the science of eugenics.

Eugenics is the science of the improvement of the human race by better breeding, or, as Galton himself has put it, "The science which deals with all the influences that improve the inborn qualities of a race." Eugenics, then, relates to parenthood, primarily, and to marriage secondarily, in that from the eugenic standpoint the success or failure of a marriage can be measured solely "by the number of disease-resistant cultivable offspring that come from it." With the environment, the relation of parents to children after they have been born into the world, the relation of these children to human society as a whole or to the particular objects with which they are surrounded, it has nothing whatever to do.

With "social betterment," as we are in the habit of using the term, it has no connection. It assumes that the only way in which the race can be bettered is by improving the breed, not by improving the conditions which surround those who are already bred; it relates—to employ once more the phraseology of Galton—to *nature* and not to *nurture*.

The arguments which the eugenists have employed to prove their contention that the nature of man is inherent and cannot be altered by conditions of environment are much too extended to be considered in an address of this sort, so I must content myself with calling to your attention some few of the most common demonstrations which are used to make clear the position which the promoters of this science occupy. The arguments against this point of view are much more familiar to the general public, for the emphasis has been laid on environment in practically all the activities of charity organizations, social betterment movements, labor union agitation and other propaganda which have been offered to the public at large. In regard to eugenics there are very general and very serious misconceptions, many quite well-informed persons believing that eugenists aim at the elimination of the unfit, something after the manner of the ancient Spartans who destroyed all defectives who were born into their state in order that their stock should be uniformly rugged and intelligent.

We learn from H. E. Jordan that it is not now so common to attribute the fall of Rome to degeneracy following luxury and over-culture, as Gibbon tried to demonstrate, or to a malarial parasite, as urged by Dr. Ross; nor to the principle of natural racial senility which was the ingenious supposition of Prof. Ray Lankester; the more probable cause was the fact pointed out by David Starr Jordan, that the human harvest was bad; that Rome sacrificed her best manhood in war and left the business of breeding new generations to weaklings, cowards, and scullions. This is exactly the situation

which the great European nations face today. While our loss in the war just past was in no wise comparable to theirs, the same problem is present in this country, because there is a constant tendency toward relative and absolute sterility among that class of society which is best fitted to produce the next generation, and the most prolific are the less fit to carry on the torch of our civilization.

The scientific basis upon which a remedy for national death, "race suicide," as Theodore Roosevelt so often reminded us, rests upon our knowledge of heredity. An understanding of the mechanism of the inheritance of physical characteristics is necessary if we are to comprehend the foundation upon which the science of eugenics rests.

When we begin to apply the principles of heredity to mental peculiarities we enter upon a subject of practically unlimited extent. Take for example, feeblemindedness, which has been extensively studied by Dr. Goddard, head of the training school for such unfortunates, at Vineland, New Jersey. By repeated tests and observations he has demonstrated that when both parents are feeble-minded all of the children will also be so; but if one parent be normal and of normal ancestry, all of the children may be normal; whereas if the normal mate have defective germ cells, one-half of his progeny by a feeble-minded woman will be defective. It has been noted that feeble-mindedness and epilepsy often replace each other in a family pedigree.

Rosanoff has demonstrated that if both parents are the victims of maniac depressive insanity or of dementia precox, their entire family will be neuropathic, but if one parent only comes from weak stock and if affected, only half of the children are liable to go insane; and lastly, that such "nervous breakdowns" do not occur in families where both parents are sound and from untainted stock.

Fallacy of "The Melting Pot"

The principal fact to be drawn from the most recent and exact scientific investigations is that the blending of family or racial traits does not take place, and the "melting-pot" in which men of every nation under heaven could be converted into a homogeneous nation is naught but a phantom of the imagination. It has been proved that unit characters do not blend and after many generations a certain given characteristic may crop out all uninfluenced by repeated unions with foreign germplasms. This forces us to the conclusion that the influence of the individual on the race is a thing of prime importance, and the responsibility of every potential parent looms full of significance to all his fellow citizens. The chance of being "lost in the crowd" becomes relatively much smaller.

Galton's first studies were made particularly to show that heredity had much more influence than environment in determining traits of character, and he devoted his attention especially to that complex of desirable mental characteristics which we term *genius*. One study was upon Fellows of the Royal Society which usually lists among its members most of the eminent scientists of the British nation. Galton assumed that at least one per cent of such a membership might reasonably be expected to be "noteworthy." As a rule not more than one in four thousand of our population gets his name in *Who's Who*, which is only one-fortieth of one per cent. Galton's results showed that on the basis of one per cent the fellows of the Royal Society had noteworthy fathers with twenty-four times the frequency of the general population, noteworthy brothers with thirty-one times the frequency to be expected in the general population, and noteworthy grandfathers with twelve times the expected frequency. In another study of the judges of England between 1660 and 1865—a period of slightly more than two hundred years—he found that

the chance of the son of a judge to possess extraordinary ability was just about five hundred times as great as that of a boy taken at random from the general population.

Two American Families

The study of genealogy and the cultivation of family trees has for some time been a favorite hobby among a certain class of people in the United States, but "looking up your ancestors" has been regarded as a subject for jest among the great majority of our people. Some of these pedigrees, however, have a very direct bearing on the subject we are discussing. As examples I will mention the histories of two "old American families," the descendants of Elizabeth Tuttle and those of "Ada Jukes."

"'On November 19, 1667, Elizabeth Tuttle married Richard Edwards, of Hartford, Connecticut, a lawyer of high repute and great erudition. Like his wife, he was very tall, and as they walked the Hartford streets together their appearance invited the eyes and admiration of all.' In 1691 Mr. Edwards was divorced from his wife on the ground of her adultery and other immoralities. After his divorce, Mr. Edwards remarried and had five sons and a daughter by Mary Talcott, a mediocre woman, average in talent and character, and ordinary in appearance. 'None of Mary Talcott's progeny rose above mediocrity, and their descendants gained no abiding reputation.'

"Of Elizabeth Tuttle and Richard Edwards, the only son was Timothy Edwards, who graduated from Harvard college in 1691, gaining simultaneously the two degrees of bachelor of arts and master of arts—a very exceptional feat. He was pastor of the church of East Windsor, Connecticut, for fifty-nine years. Of his eleven children, the only son was Jonathan Edwards, one of the world's greatest intellects, pre-eminent as a divine and theologian, president of Princeton college. Of the descendants of Jonathan Edwards much has been written; a brief catalogue must suffice: Jonathan Edwards, Jr., president Union College; Timothy Dwight, president of Yale; Sereno Dwight Edwards, president of Hamilton College; Theodore Dwight Woolsey, for twenty-five years president of Yale College; Sarah, wife of Tapping Reeve, founder of Litchfield Law School, herself no mean lawyer; Daniel Tyler, a general of the Civil war and founder of the iron industries of Northern Alabama; Ann Maria, wife of Edward Amana Park, president of Andover Theological Seminary, herself as astute a thinker as her clerical spouse; Timothy Dwight, the second, president of Yale University from 1886 to 1898; Theodore William Dwight, founder and for thirty-three years warden of Columbia Law School; Henrietta Frances, wife of Eli Whitney, inventor of the cotton gin, who 'burning the midnight oil by the side of her ingenious husband, helped him to his enduring fame'; Merrill Edwards Gates, president of Amherst College; Catherine Maria Sedgwick, famous authoress; Charles Sedgwick Minot, authority on biology and embryology in the Harvard Medical School; Edith Kermit Carow, wife and co-worker of Theodore Roosevelt; and Winston Churchill, one of the best known of American novelists." These constitute a glorious galaxy of America's great educators, students and moral leaders of the Republic.

"Two other of the descendants of Elizabeth Tuttle, through her son, Timothy, have been purposely omitted from the foregoing catalogue because they inherited also the defects of Elizabeth's character. These two were Pierrepont Edwards, who is said to have been a tall, brilliant, acute jurist, eccentric and licentious; and Aaron Burr, Vice-President of the United States, in whom flowered the good and evil of Elizabeth Tuttle's blood.

"The remarkable qualities of Elizabeth Tuttle were in the germplasm of her four daughters also. Among their

descendants were: Robert Treat Paine, signer of the Declaration of Independence; the Fairbanks brothers, manufacturers of scales and hardware at St. Johnsbury, Vermont; the Marchioness of Donegal; Morrison R. Waite, Chief Justice of the United States; Melville M. Bigelow; Marvin Richardson Vincent, professor of Sacred Literature at Columbia University; the Marchioness of Apesteguia of Cuba; Ulysses S. Grant, and Grover Cleveland, presidents of the United States." So the germplasm which Elizabeth Tuttle received from her forbears was handed down to enrich every department of government, of learning and culture throughout the history of this nation.

Turning now to the family of "Ada Jukes," who is also known to students of eugenics as "Margaret, the mother of criminals," her actual family name being concealed for reasons which can readily be appreciated, we find that she was of Dutch ancestry, living some time after the year 1800. She was one of six sisters, and her progeny and those of two of these sisters have been exhaustively studied, first by R. S. Dugdale, and again in 1915 by A. H. Estabrook, of the Carnegie Foundation.

"We find among the males (of Ada Jukes' descendants) twelve criminals, one licentious, five paupers, one alcoholic and one unknown; none was a normal citizen. Among the females, eight were harlots, one a pauper, one a vagrant and one unknown; none was known to be reputable."

Altogether it has been estimated that the progeny of Ada and her sisters have cost the State of New York over a quarter of a million dollars up to the year 1877, and although the family has now disappeared from Ulster County, where they long had their habitat, and are scattered all over the country, their anti-social traits are still being perpetuated, though better matings have occasionally helped to produce better individual members. Popenoe remarks in a footnote that "while such marriages may be good for the Jukes family, they are bad for the nation as a whole, because they tend to scatter antisocial traits."

The consideration of such family histories as the two just given naturally leads us to ask: How can "good blood" be perpetuated and encouraged to increase? And also: Is there any way by which the breeding of paupers, criminals and mental deficients can be stopped or diminished?

The Chief Aim of Eugenics

The elimination, or at least the diminution of the unfit has come to be generally regarded as the chief aim of eugenics. This is a mistake. The emphasis should be laid rather on the desirability, more than that the vital necessity, of increasing the numbers of the fit; in other words, it is of more importance to breed abundantly from the good stock than it is to decrease the breeding of defective stock. We can mournfully reckon in dollars and cents what it has cost a certain state to maintain a race of paupers and criminals up to the number of twelve hundred or more, but who can reckon the money value which such as the Edwards family has added to our entire country? It lies within the power of every right-minded man and woman to help along the improvement of the race. Those who are not themselves fitted to add to its stock of fine specimens can aid those who are so fitted to mate properly and reproduce abundantly. George Ade has spoken somewhere of the girl who preferred "to shop around for a husband." If more opportunities were given to all young people to "shop around" and more than that to follow the Christmas slogan to "shop early," we would have better stock to breed from for more reasons than I have time to enumerate.

A few weeks ago the Fifth Avenue Coach Company, a corporation operating the motor buses in New York City, printed and distributed a pamphlet

among its employees and patrons which was of special eugenic interest, although it was not a scientific treatise, and the word "eugenics" did not occur in it. The slogan of this company is "Civility," and this pamphlet contained more than three hundred and fifty pictures of small children, sons and daughters of the company's employees, or as they termed them, the "children of civility." It is this company's unexpressed intention to ameliorate the public manners of the citizens of New York—which everyone admits leave much to be desired—by setting them an example of politeness in the persons of the company's employees who serve this public, and it proposes to rear a breed of civil people by encouraging its men to marry and raise large families, or as they put it, to "out-populate the barbarian." This idea is worthy of consideration by all thoughtful people, and is infinitely more important than the consideration of the ethics and advisability of the sterilization or segregation of the unfit, although I do not wish to be understood as in any way belittling that side of the question. The maintenance of the superiority of any race depends in the last analysis upon the number of superior individuals of which that race is composed, not in the number of inferior ones that are missing from it.

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Embryology and Heredity

Kompendium der Entwicklungsgeschichte des Menschen, mit Bereucksichtigung der Wirbeltiere, by Dr. L. Michaelis, Privatdozent an der Universitaet Berlin. Ninth edition. With 54 text figures and two plates. Pp. 160. Price, 65 cents. Leipzig, Verlag von George Thieme, 1921.

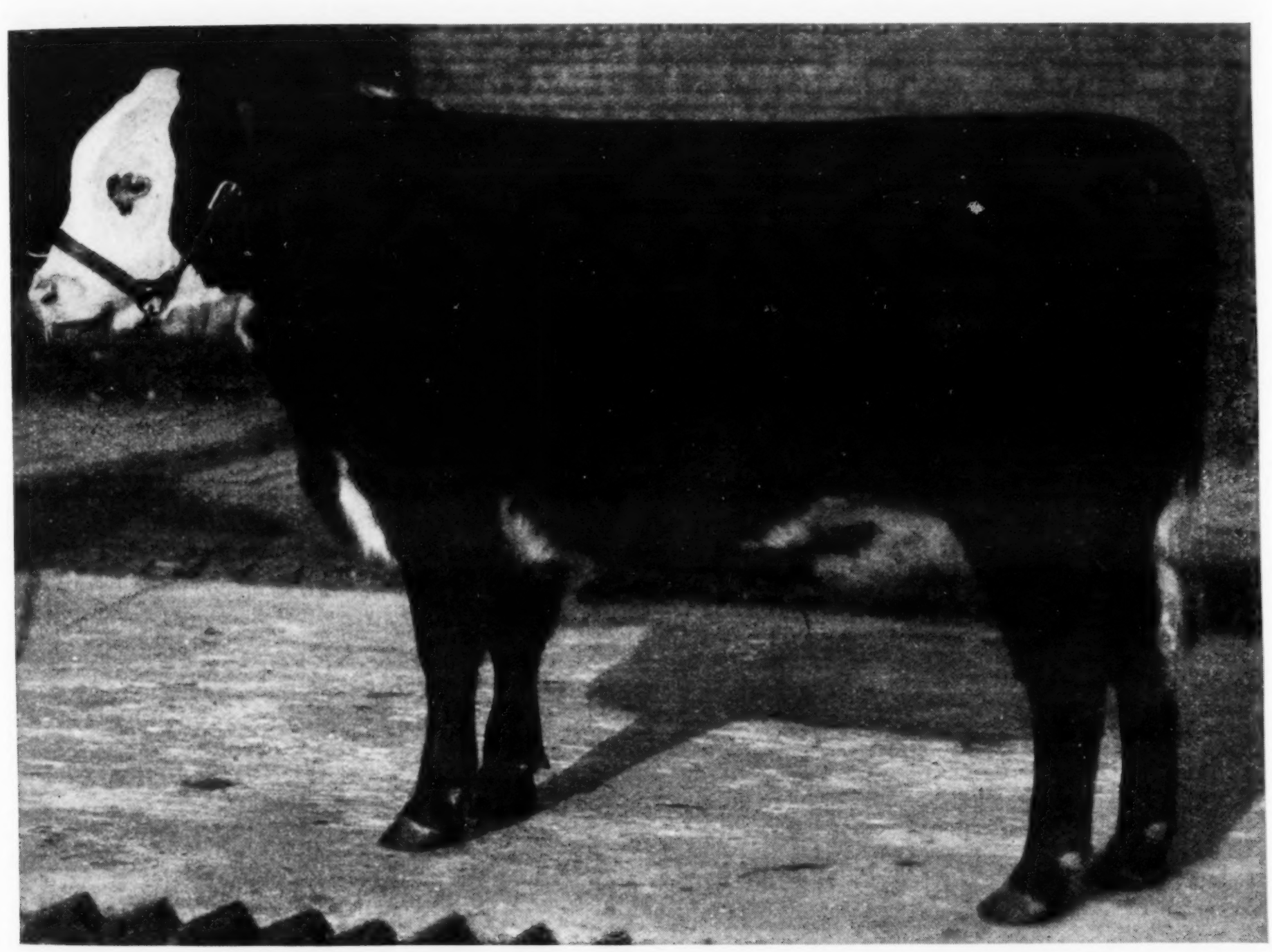
Thirty or forty years ago the study of embryology was much more popular than it is at present, when genetics and other lines of investigation have taken its place as the fashionable kinds of research. It may be that embryology had for the time being reached a point where it repaid attention less than some other branches of biology; but these other branches, and genetics in particular, have now reached a point of development where emphasis on the embryological side is highly important. All tools for the worker are welcome, and Dr. Michaelis' survey of the field is so compact yet full of material that it should be widely useful for the pocket as well as the work table.

—P. P.

UNUSUAL COLOR INHERITANCE

COAT COLOR OF CROSS-BRED STEER, QUOMAN'S PERFECTION, NOT THAT ORDINARILY ENCOUNTERED IN THE ANGUS-HEREFORD CROSS

GEORGE S. TEMPLETON
A. and M. College, College Station, Texas



A RED ANGUS-HEREFORD BULL

FIGURE 16. Normally the first generation of the Angus-Hereford cross has the black body-color of the Angus and the white face of the Hereford. However, Quoman's Perfection is an exception, being red instead of black. Two other typical Angus characteristics appeared, the polled head and barrel-like body. Evidently his sire carried the red color factor as a recessive character, although this had not been indicated by thirty-nine other matings.

THE cross-bred steer, Quoman's Perfection, bred, fed, and exhibited by the Animal Husbandry Department of the A. and M. College of Texas, attracted quite a little attention at the recent American Royal and at the International Live Stock Show, not only on account of the premiums won, but because of his unusual coat color.

Quoman's Perfection won first in the senior Angus steer calf class, was reserve champion Angus steer, and a member of the first prize Angus herd of three steers at the American Royal. Two weeks later at the International, in a strong class of forty-five entries of grade and cross-bred steers, Quoman's Perfection stood second to the sensational California steer calf, and he was first prize grade Angus steer calf.

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among its employees and patrons which was of special eugenic interest, although it was not a scientific treatise, and the word "eugenics" did not occur in it. The slogan of this company is "Civility," and this pamphlet contained more than three hundred and fifty pictures of small children, sons and daughters of the company's employees, or as they termed them, the "children of civility." It is this company's unexpressed intention to ameliorate the public manners of the citizens of New York—which everyone admits leave much to be desired—by setting them an example of politeness in the persons of the company's employees who serve this public, and it proposes to rear a breed of civil people by encouraging its men to marry and raise large families, or as they put it, to "out-populate the barbarian." This idea is worthy of consideration by all thoughtful people, and is infinitely more important than the consideration of the ethics and advisability of the sterilization or segregation of the unfit, although I do not wish to be understood as in any way belittling that side of the question. The maintenance of the superiority of any race depends in the last analysis upon the number of superior individuals of which that race is composed, not in the number of inferior ones that are missing from it.

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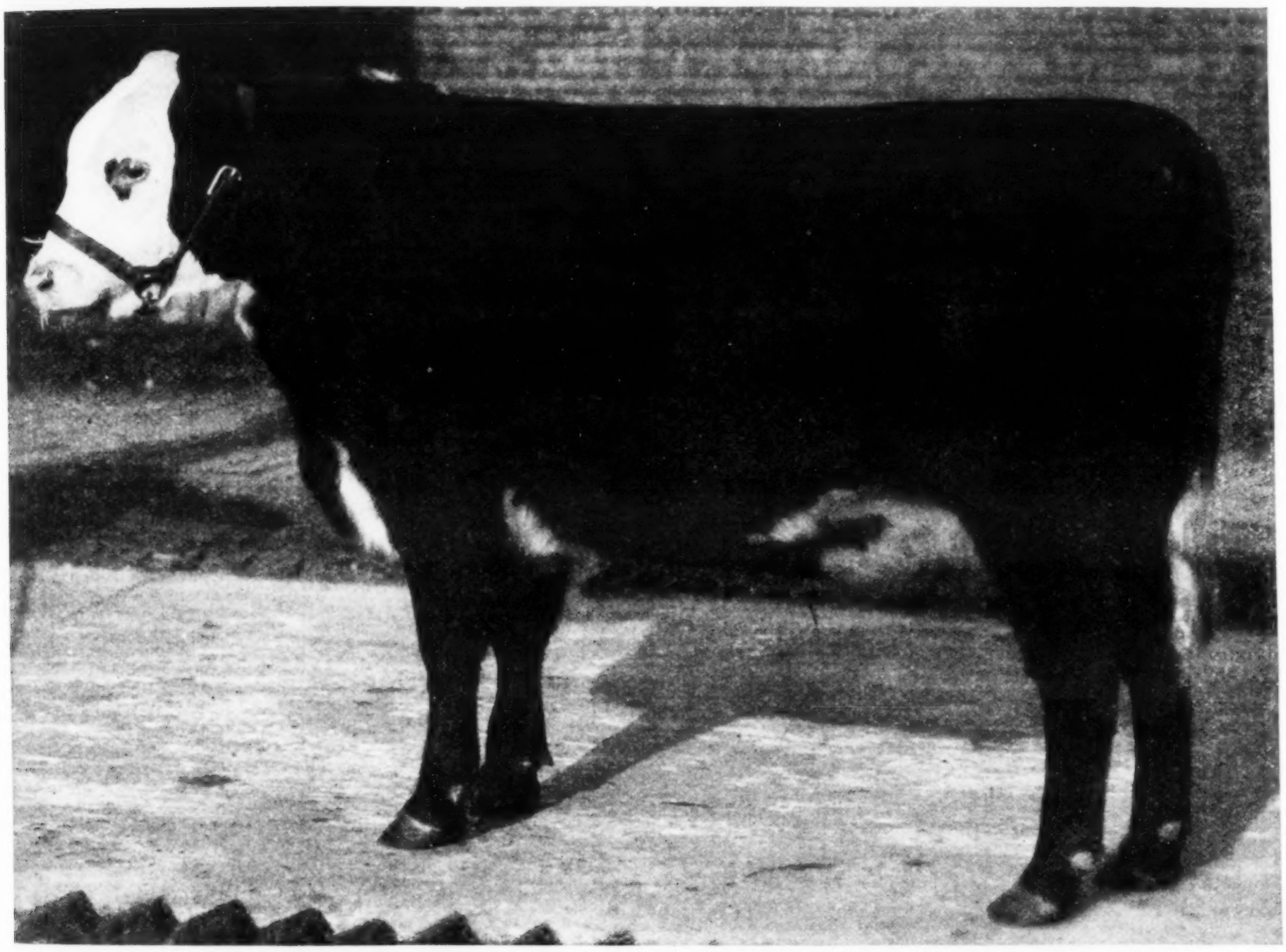

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The sire of Quoman's Perfection is

the Angus bull, Quoman of Tierra Alta 248048. This bull was used for several years at the head of the College herd of Angus. During the five years that he was in service he sired thirty-five calves out of pure-bred Angus cows, one out of a grade Shorthorn, and three out of grade Jerseys. All of the thirty-nine calves sired by this bull were black. The dam of Quoman's Perfection, Belle Perfection 46th 493840, a Hereford cow, has produced four pure bred Hereford calves, all normal in color. As this cow did not "nick" well with the Hereford herd bull, and as steers were so valuable for class work, it was decided to cross breed this cow with a bull that would be more likely to "nick" with her particular type for the production of a more desirable type of steer.

On the arrival of the calf, October 28, 1921, the little fellow instead of being black bodied with white face (the color so common in this cross) was red bodied with white face. It was at first thought that there had been a mistake in the mating. By referring to the breeding records, however, it was found that the cow was mated with the Angus bull. Upon close examination of the calf it was found that he had a dark muzzle and a dark tongue which partially established the fact that his sire must be the Angus bull. As he matured the horns failed to make their appearance, a typical poll head developed, and the cylindrical turn of the body, so characteristic of the Angus, became more evident. There can be no mistake as to the steer being an Angus-Hereford hybrid. The three dominant characters usually so evident in a cross of this kind are the poll head, white face, and the black body. The first two characters named have bred true in this particular case, but how about the red color of the body coat?

Although Quoman of Tierra Alta has never sired a red calf in the thirty-nine matings referred to above, he must undoubtedly be heterozygous for coat color. In this particular mating a male gamete bearing the red color has undoubtedly fertilized the female red gamete and the calf, Quoman's Perfection, is the result of the homozygous zygote.

According to figures given in Wisconsin Experiment Station *Bulletin No.* 213, dealing with the inheritance of the red color in the black breeds of cattle, 2.61 per cent of the Angus recorded in Vols. 18 to 27 inclusive are heterozygous for red.

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A NEW METHOD OF SELF-POLLINATING CORN

MERLE T. JENKINS,

U. S. Department of Agriculture, Washington, D. C.

EXTENSIVE cooperative corn breeding experiments were inaugurated at Ames, Iowa, in 1922, by the Office of Cereal Investigations, U. S. Department of Agriculture, and the Iowa Agricultural Experiment Station. It was necessary to make a large number of self-pollinations in connection with these investigations, and a modified technique has been developed that is efficient both as to time and results. Because of the interest in selection within selfed lines as a means of corn improvement and the large number of selfs that are being made each year, it seems desirable to present the modification at this time.

A method of hand-pollinating used in the Office of Cereal Investigations for some years has been as follows: The ear-shoots are bagged before any silks have appeared. After a few silks emerge, the shoot is cut back ½ to 1½ inches and the bag is replaced. In from twenty-four to forty-eight hours a good brush of silks some two inches long is ready to pollinate. The method of bagging and cutting back shoots is illustrated. in Figure 17. The tassel required for any pollination may be bagged at the time of cutting back the given shoot. From twenty-four to forty-eight hours' protection from stray pollen is thus given, during which time any foreign pollen that previously had lodged upon the tassel may lose its viability.

Bags of glassine paper two and one-half inches wide and six inches long have been found convenient for bagging the shoots before pollination. As they are semi-transparent, the development of the silks may be watched and the time otherwise required to feel each shoot is saved. The size of the bags is such as to give sufficient room and yet to stay in place without fastening. Occasionally a bag is lost, but a little practice in using them reduces this loss to a minimum. Heavy twelve-pound paper bags have been used for the tassels in selfing and the same bag is used to protect the shoot after pollination.

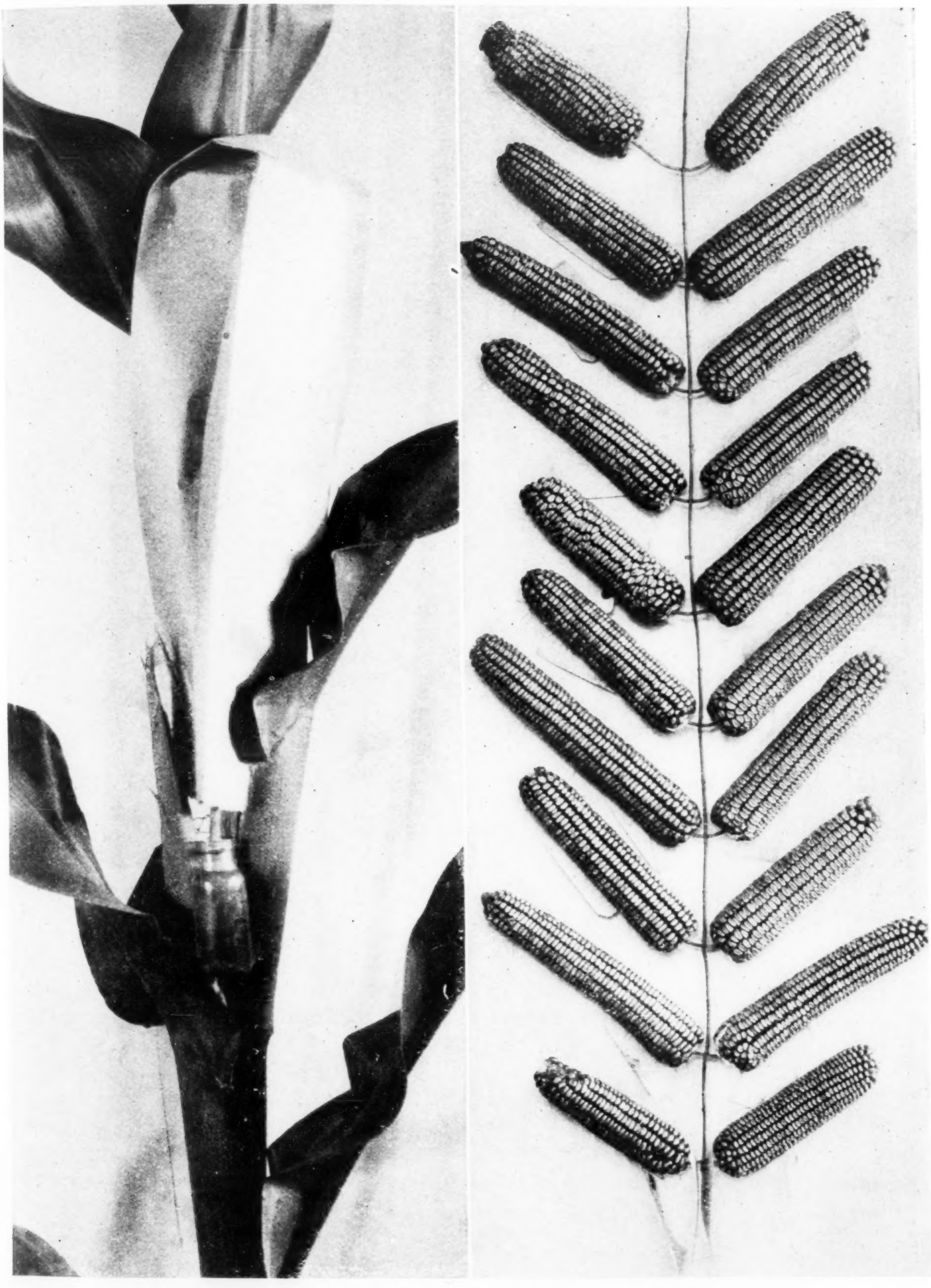
The method used in 1922 was similar to this up to the time of cutting back the shoots. At this time the tassel was pulled, shaken to free it from foreign pollen, and enclosed with the shoot in a twelve-pound bag. In order to keep the tassel shedding, its stem was inserted into a small bottle of water that had been attached to the stalk.

It was found desirable to have two men operate together. One carries tags for labeling the ears and a pail of water containing a supply of small, wide-mouthed bottles. Operating from the side of the plant bearing the ear-shoot he first fastens a tag just above the ear-bearing node, and then fastens one of the small bottles of water to the stalk just above the tag. The tag should be to his right and the bottle to his left as he faces the plant.

The other man carries a supply of twelve-pound paper bags, paper clips or string, and a knife. Operating from the opposite side of the plant, he pulls the tassel, frees it from pollen by shaking, and puts it into one of the bags. He then removes the glassine bag, cuts back the shoot, and places the bag containing the tassel over the shoot, inserting the stem of the tassel into the bottle of water. The stem should be kept to the back of the bag (away from the stalk) and to the right for convenience in handling.

TECHNIQUE OF THE NEW METHOD

FIGURE 17. Before the silks appear a glassine bag is placed over the ear. After the silks are visible the end of the husk is cut back, and the tassel of the plant is removed and shaken to free it from foreign pollen. Then a twelve-pound paper bag is slipped over both tassel and ear and fastened in place. The stalk of the tassel rests in a small bottle of water to prevent it from withering before a considerable quantity of pollen has been shed.



POLLINATION COMPLETED—TYPE OF EARS OBTAINED

FIGURE 18. The advantages claimed for this method of self-pollinating corn are that it prevents danger of contamination and that the ears produced are well filled from base to tip. About forty-five pollinations an hour can be made by two men. The method does not lend itself well to cross-pollenation, but by using individual branches of the tassel a useful modification might be developed.

During this operation he is assisted by the first man, who holds the leaf away so that the bag may be pulled well down over the shoot. The bag then is fastened in place.

The bag may be tied in place with string or wire, or may be fastened with paper clips by bringing the two front corners of the bag (toward the plant) forward around the stalk, folding them, and clipping. This method is shown in Figure 18, which illustrates a plant on which pollination has been completed. The use of clips has several advantages. The corners of the bag not clipped accommodate the growth of the shoot so that little further attention is required. There also is less damage from rain, as the attachment to the stalk helps to hold the ear erect with the bag over it like a tent.

The time required for the operation as described is about the same as would be needed to apply pollen from the previously bagged tassel under the older method. Consequently the time otherwise required for bagging the tassel is saved. Two men made 380 pollinations in six hours, under favorable conditions during the past season. This is something more than sixty per hour or one pollination per minute. The average, however, was about forty-five pollinations per hour for two men.

Pollinations may be made at any time of the day, as shedding of pollen does not have to be in progress at the time of bagging. It is necessary, however, to know that the tassel will shed pollen later on. In this connection, it has been found that tassels will shed little or no pollen if they are pulled more than a few hours before shedding begins. If pulled after the central spike has begun to shed abundantly they may continue to shed for four or five days under favorable conditions, and this is the best time to pull them.

Bottles of about one ounce capacity with a mouth about three-quarters of an inch in diameter proved the most satisfactory of several kinds tried. These were obtained at prices ranging from two to three cents each. They were left on the stalks about four days and then were collected for further use, so that only enough were needed to take care of four or five days' pollinations. Some tassels will shed satisfactorily without being put in water. The cost of the bottles is small, however, and it is safer to use them in all cases. The bottles may be attached to the stalk with copper wire (about No. 23 B&S) twisted first around the neck of the bottle and then about the stalk. The bottles also may be hooked in place by means of a stiff wire fastened to the neck and properly bent.

This method was used satisfactorily in making over 7,000 self-pollinations in 1922. A representative sample of the ears obtained is shown in Figure 18. Both yellow and white varieties of corn were grown in the pollinating plat and were shedding pollen at the same time, so that if much contamination had occurred some of it should be apparent as xenia. Most of the ears have now been shelled and very few cases of contamination have been observed. It seems likely, moreover, that there is at least as little danger of contamination in using this method as there is in any method that involves even the briefest exposure of receptive silks to a pollen-filled atmosphere.

The method can be utilized in cross pollination when it is not necessary to use the tassel more than once. It also may be possible to use only individual branches of a tassel so that several pollinations can be made from a single plant. This seems worth trying because of the safety of the method, in spite of the fact that it does not lend itself as well to the less routine operation of crossing. In self-pollination, however, the method is not only safe but efficient.

MUTATIONS OF THE POTATO

TWO SOMEWHAT UNSTABLE LEAF-FORM SPORTS OF THE IRISH POTATO

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MUTANT AND NORMAL LEAVES

FIGURE 19. While greater variation is to be expected in the progeny of plants that reproduce by seed, the breeder of those that are propagated vegetatively also has an opportunity to take advantage of variation, in the form of bud sports. Frequency of sporting varies greatly in different species; in the study here reported only five leaf-form mutations were observed in more than 350,000 plants examined. The leaves shown above are both from the same plant, the fifth vegetative generation of a thick-leaved mutant discovered in the Green Mountain variety. The leaf on the right is typical of the mutant form, while the other has partly reverted to the normal.

VARIEGATION sports of the Irish potato have been reported by Quanjer[1]* and by Hungerford,[2] and have been observed by the writer. MacKelvie[3] has described a sport with simultaneous loss of tuber-skin color, change of sprout color, and decrease in abruptness of tapering of the distal ends of the leaflets. Leaf-form sports appear to be infrequent in potatoes. The two types reported here seem to be somatic mutations in

*For numbered references, see Literature Cited at end of article.

A SIMPLE-LEAVED VARIATION

FIGURE 20. This plant represents the second vegetative generation of a simple-leaved strain discovered in the White Mountain variety in 1920. A tuber of this plant gave rise to the plant shown in Figure 21, the leaves of which were partly of the normal form, but the vegetative progeny of the latter were all simple leaved.

PARTLY REVERTED

FIGURE 21. This plant was raised from a tuber of the simple-leaved plant shown in Figure 20. Two of its leaves were half simple and half compound, but the plants raised from it were all simple-leaved. The fact that these plants partly revert to the normal after two generations of abnormality precludes the possibility of their unusual leaves being due to "degeneration disease." From this there is no recovery as long as vegetative propagation is continued.

a clonal variety, and have been unstable enough to revert in part to the varietal norm. The five cases to be described were the only ones noticed in over 350,000 plants observed for foliage diseases.

A simple-leaf sport of the Green Mountain variety came under the writer's observation in northeastern Maine in 1920 as a single hill in a commercial field. The second, third and fourth generations* were grown respectively in the greenhouse at Orono the following winter (Fig. 20), in the field in the summer of 1921, and in the field in 1922. The third generation (consisting of a one-stalked plant) apparently reverted partly to a compound-leaf condition, two leaves being divided longitudinally so that each was half simple-leaf and half compound-leaf (Fig. 21), but its five tubers produced

*The *generations* referred to in this paper are vegetative ones and not sexual generations.—Editor.

ten plants that were simple-leaf throughout.

Four thick-leaf sports have been observed by the writer in four different Maine fields, three in the Green Mountain variety and one in the Ehnola variety. Only one will be described here. It originated in a Green Mountain hill-selection strain grown and observed for foliage diseases from 1915 to 1920, inclusive. This hill-selection strain produced only one thick-leaf sport, as one hill in a total of 158 grown in 1918. The original thick-leaf hill had two branches almost normal and two branches with distorted, thick or fleshy, glabrous leaflets. Of the second, third, fourth and fifth generations, grown in the field the next four summers, each showed a range from absence to completeness of sporting among the various hills, and even among the various leaves of one hill, and among the leaflets of a single leaf. Fig. 19 shows a completely abnormal leaf and one partly normal. The original plant in 1918 yielded six tubers, which in 1919 produced sixteen plants of which nine were more or less abnormal. Seven of these nine hills were kept. The percentage of their leaf area estimated to be abnormal, ranging from ten to one hundred per cent for the different plants, was not correlated with the abnormality percentages of their progeny hill-lots. In 1920, ten hills were selected as having less than half of the foliage abnormal, and ten with more than half. These two ten-hill parts of the strain were not obviously different from each other in 1921, though as previously stated, there was a complete range of difference between hills. Only a few of the most abnormal hills were kept in 1921, but in 1922 there was again a variation, normal or partly normal foliage appearing. It seems, then, that the thick-leaf type of sport, though probably occurring more frequently than the simple-leaf type, is somewhat less stable.

Partial recovery after two generations of complete abnormality, with normal leaflets or leaves then appearing with abnormal ones as parts of the same structure, precludes these sports from being classed with degeneration diseases. From such diseases there is no true recovery as long as propagation is by tubers,[1] and apparent recovery (climatic suppression of symptoms) is not confined to indiscriminately scattered leaflets, leaves, and plants.

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